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3rd European Squirrel Workshop
- Abstracts -

Foreword and Acknowledgements

There have been two previous European Squirrel Workshops. The first one was held in September 1992 in Portovaltravaglia, Italy. The second took place during the 2nd European Congress of Mammalogy in March 1995 in Southampton, England. Both these workshops were very fruitful and provided a welcome and needed opportunity for the scientific exchange of information on current squirrel projects and research.

Following my own work on red squirrels (*Sciurus vulgaris*) in the Bavarian Forest National Park, the Park administration generously offered to host the 3rd Workshop in September 1995. It seemed a risk to invite people from all over Europe to a workshop held in such a remote place as the Bavarian Forest. However, the response exceeded all expectations and 34 delegates from 12 different countries including Sweden, Britain, Netherlands, Portugal, Spain, Italy and Israel gathered in Neuschönau on 11th September 1995 for five days of intensive lectures, discussions and exchanges of ideas.

Squirrel research in Europe has become increasingly important over the last decades. The introduction of the alien North-American grey squirrel (*Sciurus carolinensis*) and its successful spread over the British Isles caused considerable economic losses as a result of tree damage from bark stripping and the displacement of the native red squirrel. The grey squirrel was also introduced to Italy and there are two well established populations in the north around Turin and Genoa. This species represents a major threat to the native European red squirrel, and a problem for which there is no simple solution. Cooperative scientific research and an exchange of experiences are needed to determine suitable control and conservation strategies to prevent these introductions from causing further damage.

In areas still devoid of grey squirrels, increasing fragmentation of the landscape due to human activities also causes problems for the red squirrel by reducing the availability of suitable woodland habitat. Fragmentation effects on squirrel populations are to be expected, but an evaluation of these effects is urgently needed if we are to provide information of general utility for future landscape management.
Against this background, two main topics were selected for particular attention in the course of this workshop:

(i) the ecology of squirrels in fragmented landscapes, and (ii) feeding ecology and the effects of food supplementation. Other papers contributed to sessions on squirrel ecology, morphology and conservation.

Some papers dealt with new results from established research projects which could have been converted into full scientific papers. Others gave preliminary results of research projects that are still in progress. As a record of the main points discussed at the meeting, we decided to publish a collection of long abstracts with a combined reference section at the end. A summary of the discussions arising from the two main sessions is also included.

The scientific programme also included two field trips. In a short excursion we visited the two squirrel research sites in the Bavarian National Park - one located in the mixed forest zone and one in the higher altitudes with natural mountain spruce forest. The main excursion of the workshop was led by Dr. Wolfgang Scherzinger, the zoologist of the National Park.

Dr. Scherzinger's tour through a naturally structured part of the Park and his knowledgeable explanations were greatly appreciated. We are all most grateful to the National Park administration for their hospitality. Special thanks goes also to the staff of the „Jugendwaldheim" for making everybody feel at home during our stay.

I personally would like to thank John Gurnell for his advice and support during the preparations for this event. My special thanks to those colleagues that helped with chairing workshop sessions. Peter Lurz helped editing the abstracts. I am also indebted to Kristin Zscheile and Holger Ebersbach for their invaluable support during the workshop itself: you sure kept things running! Last but not least, my personal gratitude goes to all the delegates, who created a relaxed and cooperative atmosphere with lively discussions, which made the workshop such a success for all participants.

Sibylle Münch

1. LANDSCAPE ECOLOGY - FRAGMENTED HABITATS

1. Landschaftsökologie und fragmentierte Lebensräume

Effects of habitat fragmentation on the Red squirrel (*Sciurus vulgaris* L.)

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In 1988 a study on the effects of habitat fragmentation on the Red squirrel was started. During 4 years the presence and absence of squirrels was monitored in 49 mixed woodlots, by searching for dreys. The woodlots range in size from 0.5 to 14 ha and are part of an agricultural landscape (Twente, NL), with a mean woodlot size of 2 ha. The number of years occupied was analyzed using logistic regression. In all models, habitat quality was taken into account by adding the area conifers in a woodlot as the first variable. Several spatial variables were tested from which the model with area of conifers, the amount of woodlots and the amount of hedgerows within 200 to 600 m gave the best fit (APELDOORN et al. 1994).

The results suggested that small remote woodlots (about 500 m far from the nearest woodlot) with poor habitat quality have the lowest occupancy chance. It was however not clear if this meant that squirrels cannot reach these woodlots because of their remoteness, or that they can be reached, but are too small and poor in terms of habitat quality to be occupied. Further more the results indicate that hedgerows affect the chance of a woodlot being occupied, suggesting that they are used during dispersal or daily movements of animals that use more than one woodlot. In the summer of 1995, squirrels were trapped in 10 woodlots in the same study area, to gain insight in these questions.

In total 22 squirrels were radio tagged and located twice a day until 25 to 30 fixes were collected. Due to predation and transmitter failure, home ranges could only be calculated for 11 individuals: 6 males and 5 females. Mean 100% convex polygons gave a mean home range size of 7.7 ± 3.8 ha for males and 2.7 ± 0.7 ha for females. Core areas (70%) were: 2.9 ±1.4 ha for males and 0.9 ± 0.1 ha for females. Several animals, most males, were trapped or located in more than one woodlot, at interwoodlot distances of 500 to 750 m, proving that some squirrels do use more than one woodlot during daily movements. Furthermore, this shows that small empty woodlots at distances of 500 m are not vacant because they cannot be reached, but probably because of low habitat quality and size.
In the same area, a homing experiment was conducted to look for the role of hedgerows

during movements between woodlots. Nine trapped animals were displaced to woodlots within a 200 to 2000 m distance. Some animals were displaced more than once, resulting in 12 trials. Continued radio tracking made it possible to follow these animals during their movements. Most animals stayed over one night before leaving the woodlot. Movement periods were short in comparison to the time spent eating, resting and sleeping. Hedgerows seemed to play an important role during these movements. They were not always moving through the hedgerow, but often ran along it i.e. over the ground or a road, fleeing into the hedgerow when disturbed. Also crossing of maize and pasture was observed. But in general open areas without trees were avoided.

The results of the homing experiments show that the animals in the woodlots in Twente do not present local populations, but are part of a patchy population, with several big patches, that probably act as sources.

Effekte der Fragmentierung des Lebensraumes auf das Eichhörnchen (*Sciurus vulgaris* L.)

Zusammenfassung

In den Niederlanden wurde über 4 Jahre in 49 Waldinseln (0,5-14ha) in einer fragmentierten Landschaftschaft (Ackerfläche/Wald) das Vorkommen oder Fehlen von Eichhörnchen durch die Kartierung von Kobeln protokolliert. Kleine, abgelegene Waldinseln mit schlechter Habitatqualität und >500m Entfernung vom nächstgelegenen Waldbereich hatten nur schlechte Chancen von Hörnchen besiedelt zu sein. Die Heckendichte der Umgebung hatte einen positiven Effekt auf die Besiedlung der Waldbereiche.

Anschließend wurden 22 Hörnchen mit Telemetriesendern versehen. Streifgebiete wurden ermittelt. Einige Tiere nutzten mehrere Waldinseln, die zwischen 500 bis 750m auseinander lagen. Bei 9 Tieren wurde das Heimfindevermögen getestet. Auch hier spielten Hecken eine wichtige Rolle, offene Bereiche dagegen wurden gemieden.

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Dispersal and population dynamics of Red squirrels (*Sciurus vulgaris* L.) in an archipelago of woodland fragments

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A central hypothesis in the study of habitat fragmentation is that increasing isolation of habitat fragments decreases dispersal between them. In small populations this can lead to local extinction, compensated or not by later recolonisation, and a higher degree of inbreeding. Until now this hypothesis is supported mainly by indirect studies (correlative research).

To support the hypotheses and models on fragmentation effects, there is need for empirical data, which show (i) how different degrees of isolation effect dispersal, (ii) which mechanism causes the decrease in dispersal (a behavioural mechanism or a decrease in success of dispersers) and (iii) what the consequences of this decrease in dispersal are.

The Eurasian Red squirrel is used as study species, because densities are not too high to mark all animals in the population and because fragmentation is known to affect the dynamics of small populations of that species. The study area is an archipelago of woodland fragments situated in the province of Antwerp in Belgium. These fragments have different size, shape and tree species composition and are connected (to different degrees) by treerows and hedgerows. The 9 largest fragments are between 5 and 55 ha and there are about 30 smaller fragments.

Squirrels are (re-)captured bimonthly in all fragments during a 7-day trapping period. Each squirrel gets an ear number or a transponder (for individual recognition), is weighed, sexed, aged, its sexual status is noted and a skin sample is taken.

To get information on home ranges and dispersal, squirrels are radio-tracked (once a week for residents and every 1 or 2 days for juveniles and dispersing adults). This is done by foot, car or, if necessary, by helicopter, depending on how far the squirrels disperse.

To get information on the degree of inbreeding, mating chases will be observed. Single- and multilocus DNA fingerprinting will be used to study paternity and genetic diversity of local populations.

Food resources are estimated to see if dispersal and settlement of squirrels depend on food availability.

During the first year I found that squirrels were present in 6 of the 10 largest fragments (4-55 ha). Adult summer densities, as determined in June, were comparably low (0.10-0.22 squirrels/ha), except in the 17 ha fragment (0.90 squirrels/ha), where a lot of food is available and in the 4 ha fragment (0.70 squirrels/ha), where squirrels can rely on supplemental feeding. In several fragments there was a sex ratio >1.

Because all squirrels were permanently tagged, they could be found after they died and death causes could be determined. Predation seemed to be an important death cause (7 out of 16 dead squirrels).

There were 5 cases of dispersal with known pre- and postdispersal home range, with dispersal distances ranging from 475 to 3950 m. There were also 11 squirrels that immigrated with unknown predispersal home range and 6 squirrels that emigrated with unknown postdispersal home range.

Further research is necessary and the current project will be continued to confirm these preliminary results and to see what will happen to the local populations.

Dismigration und Populationsdynamik beim Eichhörnchen in einem Archipel von Waldinseln

Zusammenfassung

In Form einer Projektskizze und ersten Ergebnisse wird eine laufende Untersuchung in Belgien beschrieben. Sie untersucht auf welche Weise der Isolationsgrad von Waldfragmenten die Dismigration bei Eichhörnchen beeinflußt und welche Mechanismen (z. B. Verhaltensmuster oder Risiko der Disperser?) hier wirken. Waldinseln unterschiedlicher Größe und Zusammensetzung verbunden durch Hecken oder Baumreihen bilden die Untersuchungsfläche. Populationsdemographie (Lebendfang) und die genetische Diversität der Teilpopulationen (DNA-Fingerprinting) werden untersucht. Per Telemetrie wird das Dismigrationsverhalten besenderter Tiere beobachtet. Die Nahrungsverfügbarkeit in den einzelnen Waldinseln und deren Einfluß auf die Dismigration wird ebenfalls getestet. Die Ergebnisse nach einem Jahr Untersuchungsdauer sind hier beschrieben.

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Presence/Absence of the Red squirrel *Sciurus vulgaris* in Danish woodlots: demonstration of fragmentation effects

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One hundred Danish woodlots, smaller than 20 ha (in East Jutland, Denmark), were checked for fresh signs of squirrel activity, e.g. food remains. Only woodlots with cone producing conifers (*Picea abies, Pinus sylvestris, P. nigra* or *Larix* sp.) were included and they were chosen to represent a wide spectrum of habitat and landscape parameters known to be important for the occurrence of squirrels in fragmented landscapes: woodlot area (0.2-20 ha), tree species composition, degree of isolation (distance to other woodlots/forests), distance to permanent squirrel populations (distance to nearest larger forest, i.e. larger than 20 ha), landscape connectivity (woodlots/forests and hedges within a distance of 500 m) (VERBOOM & VAN APELDOORN 19990, VAN APELDOORN et al. 1994). Fresh signs of squirrel activity were found in 30% of the woodlots. Larger forests were supposed to be permanently inhabited by squirrels. This was confirmed by the presence of fresh squirrel signs in a control group of 11 forests larger than 20 ha.

Three parameters contributed significantly in a logistic regression analysis to the explanation of variation in squirrel occurrence in woodlots smaller than 20 ha: (i) number of woodlots within 500 m, (ii) distance to a large forest, and (iii) woodlot area. Overall explanation was rather poor (ca. 25%). However, the observed pattern of distribution and occurrence of squirrels in these small woodlots is taken as an demonstration of fragmentation effects.

At present 77% of the Danish forests are smaller than 20 ha. Even though they cover only 16% of the total forested area, they are very important and characteristic landscape elements. However, they represent „fragments" and as such they are suboptimal habitats for a species like the squirrel. The Danish governement intends to double the forested area in Denmark over the next 80 years. This will be a unique opportunity to improve habitat quality and landscape connectivity on a large scale. Documentations of fragmentation effects on wildlife, like presented above for the squirrel, are very important at this stage, and hopefully, they will be taken into consideration by landscape managers.
Our knowledge about squirrel biology in fragmented areas is rapidly improving in these years (WAUTERS et al. 1994). However, there are still many open questions, and there is a need for detailed, long-term studies on population fluctuations, population

dynamics, immigration and emigration patterns, exchange of individuals between populations, and habitat utilization of squirrels in fragmented areas. And, on top of this we must realize, that „fragmentation" is not an unambiguous term, as it represents a wide range of landscape fragmentation patterns.

Vorkommen/Fehlen von Eichhörnchen *Sciurus vulgaris* in Dänischen Waldinseln: Darstellung von Fragmentierungseffekten

Zusammenfassung

In Ost-Jütland (Dänemark) wurden 100 Waldinseln (Koniferen) anhand frischer Nahrungsreste auf Besiedlung durch Hörnchen untersucht. Bei der Wahl der Untersuchungsfläche wurden Lebensraumparameter, die für Hörnchen relevant sind wie z.B. Baumartenmischung, Größe und Isolationsgrad der Waldinsel sowie Distanz zur nächsten Hörnchenpopulation berücksichtigt. Bei der Besiedlung der Waldinseln durch Hörnchen erwies sich die Anzahl anderer Waldinseln in < 500 m Distanz, die Entfernung zum nächsten größeren Wald und die Größe der Waldinsel als entscheidend. Die Ergebnisse werden auf dem Hintergrund der derzeitigen, geringen Größe der einzelnen Waldflächen in Dänemark und im Hinblick auf geplante zukünftig verstärkte Aufforstung diskutiert. Auf Konsequenzen für die Landschaftsplanung wird hingewiesen.

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Eurasian Red squirrels (*Sciurus vulgaris*) in two different landscapes - a comparison

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Eurasian Red squirrels (*Sciurus vulgaris*) were studied in two different landscapes in south-central Sweden: a forest landscape and a farmland-forest landscape. Some of the parameters that were studied were the squirrels´ habitat selection and home range size in relation to habitat fragment size, and the proportion of different habitat categories in the two landscapes.

In the forest landscape, the squirrels showed a strong preference for forest older than 35 years and with more than 25% Norway spruce (*Picea abies*). This preferred habitat constituted 24% of the study area. The proportion of avoided habitats was 31%, and the remaining 46% could be described as used but not preferred habitats. Given these proportions, the squirrels can be shown theoretically to be able to reach all preferred patches by moving across the used, although not preferred habitat patches, or within the preferred ones.

Males had larger home ranges (mean 99 ha) than females (mean 18 ha). Most of the preferred habitat occurred in fragments larger than the area requirement of an individual squirrel, and even the most isolated fragments were within the trivial range for squirrels. The effects of fragmentation is therefore predicted to be only a loss of habitat; no isolation effects were found.

In the farmland-forest landscape, the forests occurred as woodlots ranging in size from 0.5 to 20 ha and constituted 15% of the study area. The woodlots were intervened by agricultural land which constituted 85% of the study area.

In this landscape, the squirrels preferred forest older than 35 years and with more than 50% Norway spruce. This habitat constituted 46% of the total woodlot area, but only 3% of the whole study area. The proportion of avoided habitat within the woodlots was 10%, but together with the agricultural matrix, the proportion of avoided habitats constituted 95%. 42% of the total woodlot area was used but not preferred (i.e.=2% of the whole study area).

Males had larger home ranges (mean 11 ha) than females (mean 4 ha). Except for three males, no other squirrel made excursions outside the woodlot in which it was caught. The effects of habitat fragmentation in this landscape is not clear. The smaller home ranges in this landscape could be due to the preferred habitats having higher quality here than in the forest landscape, and therefore the squirrels may not need so large home ranges to get enough food and shelter. It could also be due to higher squirrel density in the farmland-forest landscape.

The fact that almost every squirrel stayed within one woodlot could indicate isolation effects. On the contrary, this could also be due to high quality habitats and/or high squirrel density.

Part of this study was published in
ANDRÉN, H. & A. DELIN (1994): Habitat selection in the Eurasian Red squirrel, *Sciurus vulgaris*, in relation to forest fragmentation. - Oikos 70, 43-48.

Eichhörnchen (*Sciurus vulgaris*) in zwei verschiedenen Landschaftstypen - ein Vergleich

Zusammenfassung

In Zentral-Schweden wurden Europäische Eichhörnchen in einer reinen Waldlandschaft und in einer Ackerland-Wald-Landschaft untersucht. Auch das zusammenhängende Waldhabitat war nicht homogen strukturiert, sondern aus Parzellen unterschiedlicher Baumartenmischung und unterschiedlicher Lebensraumqualität für Hörnchen zusammengesetzt. Habitatwahl, Streifgebietsgröße der Eichhörnchen bzw. deren Zusammenhänge mit der Fragmentgröße der verschiedenen Waldbereiche und ebenso das Verhältnis der verschiedenen Waldkategorien zueinander werden hier für beide Lebensraumtypen beleuchtet. Effekte der Fragmentierung der Lebensraumstrukturen auf die Eichhörnchen werden diskutiert.

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Conserving the Red squirrel in Jersey - the problem of fragmented habitats

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In September 1994 a three year study began on the Red squirrels that inhabit the Channel Island of Jersey. Red squirrels were introduced to the Island approximately 100 years ago from Britain and Scandinavia, and now persist as a metapopulation in 540 hectares of mixed and deciduous woodland. The average woodland size is 2.5 hectares (0.1-31.5 ha) and the average distance between woods is 0.5 km (0.1-6.5 km). The woods are contorted and narrow with an average perimeter to area ratio of 0.019.

The Islands prebreeding population of squirrels is believed to be below 200 individuals and these are split into at least two separate populations. The woodland structure of Jersey is unusual, arising from past management and environmental stochasticity. Although the Islands woods were never contiguous, since the squirrel's introduction they have faced a continuing loss of habitat. In the Second World War many of the woodlands were felled for fuel and the resulting regrowth is of similar age and species composition. After 1974, Dutch Elm Disease, has reduced the hedgerows to 2% of their original extent removing the contiguity between many of the woodland patches. Finally a gale in 1987 reduced further the extent of the woods especially the coastal pines. A

vegetation survey has shown that the woodland species composition does not match well with those in Britain. The most common species mix in the woodlands is a co-dominant canopy consisting of *Acer pseudoplatanus, Quercus robur,* and *Castanea sativa,* the latter two providing the main food resource for squirrels but due to their masting behaviour are temporally unpredictable.

The built-up area of the Island is extensive and squirrels exploit this „urban niche" with 30% of individuals visiting gardens for supplementary feeding. Radiotracking studies are beginning to show that supplementary feeding affects squirrel home range size and shape since individuals will travel many hundreds of meters to gardens often many times in one day. These human effects are distorting the natural carrying capacity of the environment. This feeding may also be increasing female body weight and fecundity.

Conservation tactics being proposed include the re-establishment of hedgerows to increase contiguity between woodlands. Also encouraging garden feeding of squirrels in a responsible way. Management is beginning to stagger the age structure of the woodlands, care is essential so that felling does not restrict the squirrels movements between suitable patches of the woodland habitat. Replanting will increase the species diversity of the woodland in order to create a more diverse and more predictable food source for the squirrels. Central to this is the removal of *Acer pseudoplatanus* whose vigorous regeneration threatens to lower further the species diversity of the woods.

Erhaltung des Eichhörnchens auf Jersey - das Problem fragmentierter Lebensräume

Zusammenfassung

Auf 540 ha stark fragmentierter Misch- und Laubwaldbestände der Kanalinsel Jersey (Großbritannien) existiert eine Metapopulation von Eichhörnchen mit <200 Individuen in zwei Teilpopulationen. Die Population geht zurück auf Individuen, die vor ca. 200 Jahren aus Großbritannien importiert wurden. Der Wald und Heckenanteil der Insel wurde seither stark reduziert. Eigenschaften dieser Population und deren Wechselwirkungen mit dem Lebensraum werden in einer 3-jährigen derzeit laufenden Studie untersucht. Die ersten Ergebnisse zeigen, daß Zusatzfutter aus urbanen Gebieten von einem großen Teil der beobachteten Hörnchen genutzt wird. Dies beeinflußt deren Streifgebiete, Körpermasse und den Reproduktionserfolg und verändert die Lebensraumkapazität für Hörnchen. Schutzstrategien um die lokale Population zu erhalten beinhalten daher neben Heckenanpflanzungen zur Biotopvernetzung und einer adäquaten Waldbewirtschaftung auch die verantwortungsbewußte Zufütterung in privaten Gärten.

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Habitat fragmentation and dispersion of the Grey squirrel (*Sciurus carolinensis*) in Italy

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In Italy two well established populations of the introduced north-american Grey squirrel (*Sciurus carolinensis* Gmelin) live in Piedmont, south of Turin over an area of about 270 km2, and in Liguria at Genova Nervi in a green part of the city of about 2 km^2. The piedmontese population goes back to two pairs, which were imported from Washington and released near the woods of Stupinigi in 1948 (CURRADO et al. 1987). The Ligurian population originated from five individuals imported from Norfolk/Virginia and introduced into the park of Villa Grimaldi in 1966 (CAPOCACCIA ORSINI & DORIA 1991).

The area occupied by this rodent in Piedmont is mainly flat (230 m to 260 m elevation). The woods of Stupinigi are almost 900 ha barge and include 470 ha of mixed forest (mainly *Quercus robur*) with a dense shrub layer (mainly *Corylus avellana*). Commercial poplar plantations (70 ha), meadows, as well as maize and wheat fields are interspersed. To the north-east the city of Turin forms a considerable barrier for natural diffusion of the grey squirrel towards the Turin hills that are rich in gardens and fruit orchards. The surrounding plain, crossed by many canals and rivers, is intensively cultivated, mostly with cereals and poplars and contains only very few smaller natural woods with *Q. robur, Carpinus betulus, Alnus glutinosa, Robinia pseudacacia, Acer campestre* and *Salix* spp. - generally placed along water courses - and few public and private parks with old broadleaf and conifer trees (*Quercus* spp., *Acer* spp., *Fagus sylvatica, Juglans* spp., *Platanus* spp., *Fraxinus* spp., *Tilia* spp., *Aesculus hippocastanum, Corylus avellana, Betula pendula, Robinia pseudacacia, Prunus* spp., *Liriodendron tulipifera, Gingko biloba, Taxodium distichum, Taxus baccata, Cedrus* spp., *Sequoia sempervirens, Pinus* spp., *Abies alba, Picea excelsa,* etc.). These parks and woodlots have a mean size of 1.2 ha and a density of one woodlot every 2 km^2. The mean density of tree and hedgerows (1.5 km/km^2) and the mean density of poplar plantations (6 ha/km^2) are other important environmental parameters for the potential spreading of grey squirrels in this area.

Besides Stupinigi, Racconigi, an old royal residence of 170 ha, is the only large park in Piedmont that is occupied by the Grey squirrel (probably because it was introduced there also). It is situated southeast of the colonized area described above and contains

80 ha of meadows and 70 ha of old mixed wood with mainly *Acer pseudoplatanus, Fraxinus excelsior, Carpinus betulus,* and very old *Q. robur*. The population living here is apparently isolated from the other colonized areas, but is considerably closer to the Roero hills, where large hazel plantations are cultivated (BOANO et al. 1994). Here the plain surrounding this Grey squirrel area has a woodlot mean density of 0.89 ha/km^2, a tree and hedgerow density of 1.8 km/km^2, and a mean density of poplar plantations of 3.5 ha/km^2.

The estimation of grey squirrel numbers in Piedmont has led to a total of about 1,000 individuals, of which around 50 should live in the park of Racconigi and over 250 in the woods of Stupinigi.

At Genova Nervi most of the local Grey squirrel population is restricted to the urban park of about 12 ha. This area is rich in old conifers and broadleafed trees, among which besides *Pinus pinea* and oaks there are many exotic tree species. The density of squirrels in the park is considered to be comparably high (about 100 individuals). The urban Grey squirrel population seems not to have spread beyond the city limits yet. There starting from sea level to an elevation of 200 m on the apennine slopes public and privat parks and gardens would offer a quite suitable habitat for these rodents which may accelerate their spread.

Over an area of almost 2,000 km^2 surrounding and including the area already occupied by the Grey squirrel in Piedmont, different environmental parameters such as area and density of woodlots, poplar plantations and tree and hedgerows (calculated from 1:10,000 aircraft orthophotographs taken in 1991), together with the presence/absence data for Red (*Sciurus vulgaris*) and Grey squirrels as well as their estimated density, were analized using the software ArcInfo and AtlasGis in order to model potential future spreading of Grey squirrels in this landscape. Hot spots in the distribution and possible corridors were worked out and mapped for the Piedmont region. For each km^2 the linear metres of tree and hedgerows were added to the two diagonals of poplar and woodlot surfaces. The result of this operation gave a map that showed that there were no direct corridors linking the occupied area with the forests of the hills and the Alps. Only the river Pellice might represent a pathway for the expansion of this rodent towards the Alps. The rest of the plain surrounding the grey squirrel has a very poor vegetation, which is extremely fragmented and is thus very little fit for squirrel movements. On this basis counter actions and efforts will be focused to prevent further spreading of the Grey squirrels in Italy. For the area surrounding the population in Genova Nervi the environmental analysis is still in progress. At present the only real risk is transportation of grey squirrels through man, against which a local law is urgently needed.

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Fragmentierter Lebensraum und Ausbreitung des nordamerikanischen Grauhörnchens (*Sciurus carolinensis*) in Italien

Zusammenfassung

In Italien existieren zwei Populationen nordamerikanischer Grauhörnchen (*Sciurus carolinensis*), wovon eine südlich von Turin (Piedmont) und die zweite im Raum Genova Nervi (Ligurien) zu finden ist. Fragmentierte Landschaft mit hohem Ackerlandanteil bzw. Stadtbereiche trennen diese Populationen derzeit noch von größeren zusammenhängenden Wäldern, die deren Ausbreitung beschleunigen würden.

Auf 2000qkm Fläche um die Piedmont-Population wurden Parameter wie z. B. Anzahl bzw. Dichte von Waldinseln, Pappelplantagen, Hecken, Baumreihen sowie Informationen über Grauhörnchen- und Eichhörnchenvorkommen erfaßt. Mit Hilfe von ArcInfo und GIS (Geographisches Informations System) wurde ein Simulationsmodell entwickelt, welches Geländestrukturen, die eine Ausbreitung der Grauhörnchen beschleunigen könnten erkennen läßt. Dies erleichtert entsprechende Maßnahmen zur Einschränkung einer weiteren Ausbreitung dieser Tierart ergreifen zu können. Erste Ergebnisse des Projektes sind hier vorgestellt.

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Plenary Discussion and Summary on Session 1: Landscape Ecology - Fragmented landscape

LUC WAUTERS & TOMMY ASFERG

Habitat fragmentation has been recognized as a major threat to the survival of natural populations. In some countries (e.g. Holland, Belgium) this idea has even become defused at the level of governmental authorities and funds have been or will be made available to study its effect on a large number of animal species belonging to different taxa. An important element in determining effects of fragmentation on survival of the study species is the proportion of suitable habitat still present in the landscape, which - for woodland habitat - varies drastically throughout Europe. As far as tree squirrels are concerned, the following studies have been carried out or are in progress in different European countries:

woodland habitat - varies drastically throughtout Europe. As far as three squirrels are concerned, the following studies have been carried out or are in progress in different European countries:

Country	Type of Research	Species
Sweden	density index	Red squirrel
Denmark	presence/absence	Red squirrel
Holland	presence/absence, spacing behaviour, translocation (homing) experiments	Red squirrel
Belgium	demography and genetic diversity, genotypic parameters, spacing behaviour and dispersal	Red Squirrel
U.K.	presence/absence	Grey squirrel
Italy	presence/absence genetic diversity	Red and Grey squirrel Red squirrel

The results of these studies all clearly demonstrate that squirrels are negatively affected by fragmentation: they no longer occur in very small and/or strongly isolated woodlands; densities in small woodlands are lower than in -with respect to habitat quality- comparable more extensive forests and genetic diversity is reduced; the dispersal pattern shows an immigration deficit in fragments, hence gene flow is reduced and squirrels in fragments seem to be slightly smaller and more asymetric than in nearby larger woodlands.

During the discussion session all participants agreed that the most important issues that need to be taken into consideration when planning future research on habitat fragmentation in relation to tree squirrel ecology and conservation are the following: (i) the duration and the scale of the research, (ii) the methodology for data gathering and analyses, (iii) the evaluation of the importance of the certain landscape elements and (iv) the need to study the mechanisms that cause changes in demography and genetic variation.

Concerning the first issue, participants agreed on the need for long-term extensive monitoring of presence/absence data and data on (relative) densities on a relatively large scale, i.e. in large study areas containing a large amount of different-size wood-

lots. This will be necessary to understand (i) the impact of environmental stochasticity (ii) the effect of catastrophic events and (iii) the interaction between the degree of fragmentation or habitat quality respectively and the demography and survival of fragmented (meta-) populations. Basic monitoring data, drey counts and/or feeding signs monitoring should be completed with standardized data describing: the forest structure, the surrounding landscape (using GIS), the"history" of fragmentation, food quantity and quality. Often little attention is paid to the presence of predators and even less is known about the incidence of internal and external parasites in small isolated populations. All participants agreed that in future research the effects of predators and parasites should be investigated. Experimental research developed to learn how squirrels use different elements (e.g. hedge or tree rows, gardens, tree patches, ditch borders etc.) to move through „hostile" landscapes was discussed together with the implementation of its results in landscape planning. Concerning the latter we also discussed the importance of tree species composition in small woodlots for Red squirrels. Finally everyone agreed that long-term monitoring studies need to be combined with intensive short-term (±5 years) research on individually marked, radio collared squirrels in a large number of woodland fragments of varying size and degree of isolation. This will allow to understand the processes of reproduction, (local) survival, and dispersal that determins the demography of the subpopulations and of the (possible) metapopulation, as well as the gene flow between subpopulations.

Plenums-Diskussion und Zusammenfassung der 1. Sitzung: Landschaftsökologie - Fragmentierte Landschaft

Zusammenfasung

Es hat sich gezeigt, daß die Zerschneidung von Lebensräumen eine starke Bedrohung für das Überleben natürlicher Populationen darstellt. In verschiedenen Ländern (Holland, Belgien) werden von staatlicher Seite Gelder für Forschung bereitgestellt, die Auswirkungen der Fragmentierung auf verschiedene Tierarten quantifiziert. Die bisher durchgeführten und z.T. hier vorgestellten Studien zeigen in vielerlei Hinsicht, daß auch Baumhörnchen durch die Fragmentierung ihres Lebensraumes negativ beeinflußt werden.

Zukünftige Forschungsprojekte zur Habitatfragmentierung im Hinblick auf Ökologie und Schutz der Hörnchen sollten demnach folgende Aspekte besonders berücksichtigen: (i) Dauer und Ausmaß der Untersuchung, (ii) Methodik der Datenerfassung und -analyse, (iii) Bewertung der Wichtigkeit verschiedener Landschaftselemente, (iv) die bestehende Notwendigkeit die Mechanismen, welche Veränderungen in der Demographie und der genetischen Variabilität der Populationen verursachen zu untersuchen.

Räumlich ausgedehntes Langzeit-Monitoring der Hörnchenvorkommen ist grundlegend notwendig um den Einfluß von Umweltstochastizität oder von katastrophenartigen Begebenheiten zu ermessen und die Interaktion zwischen Fragmentierungsgrad oder Habitatqualität und Demographie oder Überlebensraten fragmentierter Populationen zu klären. Das Monitoring sollte komplettiert werden durch standardisiert aufgenommene Informationen über Waldstruktur und Struktur der umgebenden Landschaft, über die Fragmentierungs-"Geschichte" und die Nahrungssituation. Prädatoren- und Parasitenvorkommen sind ebenfalls wichtige Aspekte. Parallel dazu sollten intensive Kurzzeit-Studien spezielle Themen bearbeiten. Experimen-

telle Untersuchungen sollen herausfinden, wie Hörnchen sich durch ungeeignete Landschaftsstrukturen bewegen und diese Ergebnisse sollten in der Landschaftsplanung Berücksichtigung finden.

Eine derartiges Vorgehen wird es erlauben, Prozesse der Reproduktion, der lokalen Überlebensraten und insbesondere der Dismigration zu ergründen, welche wiederum die Demographie von Subpopulationen, von möglichen Metapopulationen und den Genfluß zwischen diesen Subpopulationen beeinflußt.

2. FEEDING ECOLOGY AND FOOD SUPPLEMENTATION

2. Nahrungsökologie und Zufütterung

Squirrel responses to variations in their natural food supplies

JOHN GURNELL

Red and Grey squirrels are opportunists and generalists eating a wide variety of different types of food. However, their primary food is tree seeds. Foods of apparently secondary importance include tree shoots, buds, flowers, berries, bark, lichens, and fungi and insects. However, not enough is known about the nutritional quality of tree seeds and other foods or how this affects foraging behaviour, food selection and individual survival and reproduction. For example, foods such as leaf buds and fungi are not bulky like seeds, but they may be high in essential nutrients (e.g. Ca, Na, P, Mg, K) (e.g. GRÖNWALL & PEHRSON 1994). Thus some alternative foods to tree seeds may be critical at certain times of the year (e.g. SULKAVA & NYHOLM 1987) and may be more important than hitherto realised. Despite this, the abundance of tree seeds seems to be of overriding importance in influencing population numbers. Consequently, it should be possible to explain a large amount of the variation in numbers of squirrels from year to year by measuring seed crop availability (GURNELL, in press). In fact, few studies have been carried out for long enough (e.g. >10 years) to test this idea and there are many sources of error in carrying out field studies on food abundance and population dynamics. These include the sampling design and effort used in measuring seed abundance. In fact, relative indices are often used rather than absolute quantities. Accurate counts of predispersed seed on conifers, and especially on broadleaves, are very difficult to do. Further, the timing of seed dispersal varies among tree species and years and this affects the estimation of seed abundance on the forest floor; few studies have looked at the disappearance of fallen seed through time (GURNELL 1993a). Other confounding factors include the seed predation and caching by other mammals and birds (GURNELL 1981, 1983, SMITH & BALDA 1979) as well as seed caching by squirrels (see L. WAUTERS, this Workshop). Furthermore, the influence of food availability can interact with other factors, such as winter weather masking possible

direct effects (GURNELL in press). Another practical problem related to seed abundance is the inverse relationship between tree seed abundance and trappability which can make the study of squirrel demography very difficult in certain habitats at certain times of the year (GURNELL 1983, in press). There are some long-term data sets of changes in (relative) numbers of squirrels among years; these in turn are likely to reflect changes in tree seed abundance. For example, ANDRÉN & LEMNELL (1992) made a 10 year study of Red squirrels in south- central Sweden. They found that winter population densities were related to the size of the Norway spruce cone crop one year before. The size of the Scots pine cone crop in this study did not have a significant effect. In general, the mean number of squirrels can reflect the overall carrying capacity of a habitat (e.g. GURNELL 1987, LURZ, GARSON & RUSHTON in press). However, some measure of the variability in numbers between years (e.g. the variance, or, for comparative purposes, the coefficient of variation) is more important as a measure of long-term environmental and demographic stochasticity (it is difficult to disentangle the two), for use in, for example, population viability analysis (see J. BIRCH, this Workshop). Understanding the relationship between natural food abundance and squirrel numbers is of paramount importance to understanding their population ecology. Thus, even though the effects of supplementary food on population numbers can be carried out experimentally (see P. LURZ, this Workshop), it is critical to their outcome that the abundance of natural food be taken into account. This, of course, has considerable bearing on the design of field studies.

Reaktionen von Hörnchen auf Veränderungen in der natürlichen Nahrungsgrundlage

Zusammenfassung

Grauhörnchen (*Sciurus carolinensis*) und Eichhörnchen (*Sciurus vulgaris*) sind Oportunisten und Generalisten, die eine breite Palette verschiedener Nahrungstypen konsumieren. Die Hauptnahrung besteht aus Baumsamen, welche die Hauptursache für die starken Schwankungen in den Individuenabundanzen von Jahr zu Jahr verantwortlich sind. Darüber hinaus wird zeitweilig auch Sekundärnahrung gefressen, die unter Umständen wichtige essentielle Nährstoffe enthält. Für Freilandstudien, die experimentell das Nahrungsangebot erhöhen, ist es wichtig, die natürliche Nahrungsverfügbarkeit exakt bestimmen zu können und deren Einfluß auf die Population zu berücksichtigen. Die natürliche Futterverfügbarkeit zuverlässig zu quantifizieren, beinhaltet jedoch erhebliche methodische Schwierigkeiten, die hier in einem Überblick dargestellt werden.

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The importance of food hoarding in European Red squirrels

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Food hoarding, caching food to be consumed at a later time (hours to months), occurs in many resident birds and mammals, and is considered to be advantageous because it serves to: (i) increase food availability during periods of scarcity; (ii) decrease the possibility for naive predators to find the cached food. Two major caching patterns are recognized: (i) larderhoarding, storing large amounts of food in one, or a few sites within the home range; (ii) scatterhoarding, placing one or a few food items in each hoarding site, distributing hundreds or thousands of these hoards throughout the home range.

Short-term studies have indicated that hoarders have a better body condition and a higher survival during periods of food shortage or increased energy demands than non-hoarders, but no studies have lasted long enough to demonstrate a positive relationship with longevity and/or lifetime reproductive success.

During autumn (September-November), the Red squirrel (*Sciurus vulgaris*) scatterhoards pine cones, acorns, beechnuts and other food items like hazelnuts, chestnuts and fungi within its home range, and recovers most of its caches the next spring (March-May), when energyrich seeds are no longer available in the trees. To determine whether food hoarding has fitness consequences in the Red squirrel, the activity budget and foraging behaviour of 45 radiotagged squirrels was studied from September 1985 to May 1987 in two populations (pine forest dominated by Scots and Corsican pine, with mature oak and beech trees along lanes, and deciduous forest dominated by mature oak and beech, with some birch, chestnut and some Scots pine) in Belgium. Survival and female reproductive success were monitored until 1993, when all animals had died.

On average, squirrels spent about 33 hours caching food in autumn, and recovered about 80% of their caches (between 2200 and 2900 tree seeds) between late autumn and early June. The energy content of the cached tree seeds would allow a squirrel to survive for 43 days in the coniferous forest and for 68 days in the deciduous forest, and during peak periods of hoard recovery in spring, consumption of cached seeds amounted to 15-45% of the daily energy-intake.

Individual variation in the proportion of time active spent hoarding and recovering cached seeds was high. Squirrels that hoarded food intensively also recovered more tree seeds in the pine forest, but not in the deciduous forest. On the short term, body mass of squirrels that recovered many tree seeds tended to increase during the spring breeding season, while squirrels that recovered fewer tree seeds tended to lose weight. Moreover, squirrels of both sexes that recovered many caches were more likely to survive the spring breeding season. On the long-term, hoarding behaviour was related to fitness in two ways: squirrels spending more time recovering hoards survived longer, and females that recovered many tree seeds weaned more young in their lifetime than those that spent less time recovering hoards. These data indicate that in Red squirrels, food hoarding is an adaptive foraging strategy to preserve temporarily abundant food resources for future periods of hardship, and that individuals that hoard and recover many tree seeds are favoured by natural selection.

Die Bedeutung der Bevorratung von Nahrung beim Eichhörnchen

Zusammenfassung

Eichhörnchen bedienen sich einer streuenden Bevorratungsstrategie. In zwei Populationen von Eichhörnchen in Belgien wurden zwischen September 1985 und Mai 1987 45 Eichhörnchen mit Telemetriesendern ausgestattet und deren Aktivitätsbudget bzw. ihr Nahrungssuchverhalten erfaßt. Weiterhin wurden die Lebenserwartung der Tiere und der Reproduktionserfolg der Weibchen bis zu deren Tod protokolliert. Der Anteil der Zeit, der für Bevorratung bzw. für das Aufsuchen der Nahrungs-Verstecke verwendet wurde, variierte sehr stark individuell. Auf längere Sicht beeinflußte die Bevorratung die individuelle Fitness der Eichhörnchen zum einen im Hinblick auf deren Lebenserwartung und zum anderen im Hinblick auf die Anzahl Jungtiere, die von einem Weibchen aufgezogen wurden. Bevorratung bei Eichhörnchen ist eine adaptive Strategie, die temporär im Überfluß vorhandene Nahrungsressourcen für Phasen mit Nahrungsmangel konserviert. Individuen, die viele Nahrungs-Verstecke anlegen und wiederfinden werden positiv selektiert.

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Review of squirrel feeding experiments and the effects of supplementary feeding on a Red squirrel (*Sciurus vulgaris* L.) population during cone crop failure

PETER W. W. LURZ

In a review of feeding experiments on terrestrial vertebrates, BOUTIN (1990) noted that the typical responses of bird and mammal populations to the addition of food are a two to three fold increase in population density, higher body weights of individuals and earlier breeding in the fed populations relative to controls.

Consistent with these generalisations, supplementary feeding experiments on North American Pine (*Tamiasciurus hudsonicus*) (SULLIVAN 1990, KLENNER & KREBS 1991) Douglas (*T. douglasii*) (SULLIVAN & SULLIVAN 1982), Fox (*S. niger*) and Grey (*S. carolinensis*) squirrels (BROWN & BATZLI 1985) as well as Chipmunks (*Eutamias townsendii*) (SULLIVAN et al. 1983) showed increases in density as a result of increased immigration, survival and reproductive success of females. Other studies on Fox, Grey (HAVERA & NIXON 1980) and European Red squirrels (LURZ, this study; HOLM 1991) found that feeding had little impact due to nutritionally inferior supplementary food or an abundance of natural food sources.

These studies collectively highlight the importance of experimental design and data interpretation to accurately assess the impact of supplementary feeding. For example, in some cases, significant increases in squirrel density following the onset of feeding may be explained by immigration (KOFORD 1992). Therefore there is a need to measure, not just changes in population density, but also adult and juvenile survival, female reproductive success and dispersal and home range size. There is also a need for longer term studies that include post-experiment monitoring.

Supplementary feeding of the 'endangered native Red squirrel' in Britain has been put forward as a short-term management practice that could be used to sustain threatened populations (GURNELL & PEPPER 1993). However, the benefits of supplementary feeding regimes to Red squirrels through their effects on density, body condition and reproductive success remain to be determined (GURNELL 1993b). I provided Red squirrels at Spadeadam Forest in the North of England with additional food during a period of spruce seed food shortage in 1992 and 1993. The results indicated some

effects on breeding and population turnover, but no significant increases in squirrel density relative to controls. Although squirrels appeared to respond to the provision of food, they did not remain in the feeding areas. From this it appears that providing additional food for Red squirrels in conifer plantations at times when natural food is limited (e.g. between mast years in spruce dominated plantations), may only succeed in raising squirrel density if very large amounts of food of sufficient nutritional quality are provided. The provision of 97 kg a month at a cost of £ 68 (DM 150) over 78 ha was not enough to attract Red squirrels to reside in the area. It can be seen, therefore, that the provision of additional food for Red squirrels as a short-term management tactic to support critically threatened populations, will require considerable commitment of money as well as time, in order to achieve its objective.

Übersicht über Zufütter-Experimente an Eichhörnchen und die Auswirkungen zusätzlicher Fütterung auf eine Eichhörnchenpopulation in Zeiten eines Mastausfalls.

Zusammenfassung

Eichhörnchen im Waldgebiet von Spadeadam, Nordengland wurde experimentell Zusatzfutter angeboten. Dies hatte Auswirkungen auf deren Reproduktionsverhalten und Populationsdynamik. Es gelang jedoch nicht, Eichhörnchen in Teilgebieten, die nur wenig natürliche Nahrung boten, permanent durch Zusatzfutter zu versorgen und dort zu halten. Ein Zufutter-Experiment in Fichtenwäldern zu Zeiten akuten Samenmangels, kann daher nur dann erfolgreich sein, wenn sehr große Mengen an Futter von ausreichender Qualität zur Verfügung gestellt werden.

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Supplemental Feeding - the Formby Experiment

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The effects of long-term ad-lib supplemental feeding on the Red Squirrel (*Sciurus vulgaris*) is currently under examination on the Sefton Coast, Merseyside, England. Two 40 ha costal woodland sites were chosen, both similar in all respects except for the

degree of public access and for the presence of supplemental feeding. Both study sites contain Corsican (*Pinus nigra*) and Scots Pine (*P. sylvestris*) stands interspersed with small areas of deciduous woodland. The experimental site at Formby is visited by 400,000 people each year and here many visitors feed the squirrels peanuts. The squirrels receive in excess of 2,000 kg of peanuts per annum. This is in sharp contrast to the control site at Ainsdale where there is no public access or supplemental feeding.

During each month of study, animals were trapped, weighed and measured, a number were fitted with radiotransmitters to estimate home range size, and the population density was estimated using transect lines.

There was no signigicant difference in mean body weights between the two sites when like sexes were compared; except for males in April 1994, December 1994, January 1995 ($p=0.01$) and October 1994 ($p=0.05$). Weights during this period varied from 330g to 400g.

Shin length and hind foot length were similarly compared. Again no significant differences were observed between the two sites, except that Ainsdaile male and female hind foot lengths, were significantly larger than those of Formby males.

The 1994 pre-breeding squirrel density at Formby was 3.5 squirrels per hectare and at Ainsdale 2.5. It appeared that supplementary feeding had only raised the population density by one squirrel per hectare.

Litter size at Formby was approximately 2.5 per lactating female. This is lower than the national average of three, and may be linked to the high squirrel density at Formby.

Health at both sites was generally good, although several animals were found with infestations of Sucking Lice (unidentified species) and jaw abscesses at Formby. To date, neither have been documented at the Ainsdale control site.

Very few dead squirrels were found at Ainsdale. In contrast during 1994 over one hundred deaths were recorded at Formby. At this experimental site the greatest known cause of death in subadult squirrels was starvation, often associated with a high ectoparasite load. Road casualties (30.4%), and disease (30.4%) were the main causes of adult mortality. Pre-weaning mortality at Formby was 58%, with both starvation and infanticide as contributing factors.

In conclusion, despite the fact that these findings only reflect the first years field work, it is clear that supplemental feeding can produce a mixture of positive and negative effects on the Red squirrel population.

Zusätzliche Fütterung - das Formby Experiment

Zusammenfassung

Die Auswirkungen eines langfristigen, ad lib. Fütterexperiments an Eichhörnchen (*Sciurus vulgaris*) wurde in Sefton Coast, Merseyside, England untersucht. Die Studie wurde in zwei 40 ha großen Waldstücken durchgeführt, welche einen Mischwald aus Schwarzkiefer (*Pinus nigra*) und Waldkiefern (*Pinus sylvestris*) trugen, der mit geringen Anteilen Laubhölzern durchmischt war. Die Ergebnisse zeigten, daß eine Zusatzfütterung bei Eichhörnchenpopulationen nicht ausschließlich positiv wirkt, sondern daß sie auch negative Erscheinungen in der Populationsdynamik und im Verhalten dieser Tierart mit sich bringen kann.

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The design and application of „red only" hoppers to Red squirrel (*Sciurus vulgaris*) conservation programmes in Britain

DEBBY F.E. SMITH

The definitive reasons for the decline in the distribution and abundance of the Red squirrel in Britain are not fully understood. One theory is that exploitation competition for food has been the major factor resulting in the replacement of Red squirrels by Grey squirrels (*S. carolinensis*). Grey squirrels may be favoured when food is limiting. The provision of supplementary food to Red squirrels, but not to Grey squirrels has been proposed as a tactic to maintain Red squirrel populations.

A number of designs of feed hopper have been proposed, these have worked on the principle of excluding Grey squirrels due to their higher mass or larger size. Hoppers need to be simple, effective and economic to produce and maintain. One recent design from the Forestry Commission research division has been produced and used on a large scale, both by projects and private individuals in the Midlands and Northern England. This design ejects squirrels from the floor of the hopper, both preventing them from feeding and providing a negative reinforcing stimulus. Despite working effectively during captive trials and field testing, Grey squirrels have subsequently learnt how to gain access to the food in these hoppers at many sites.

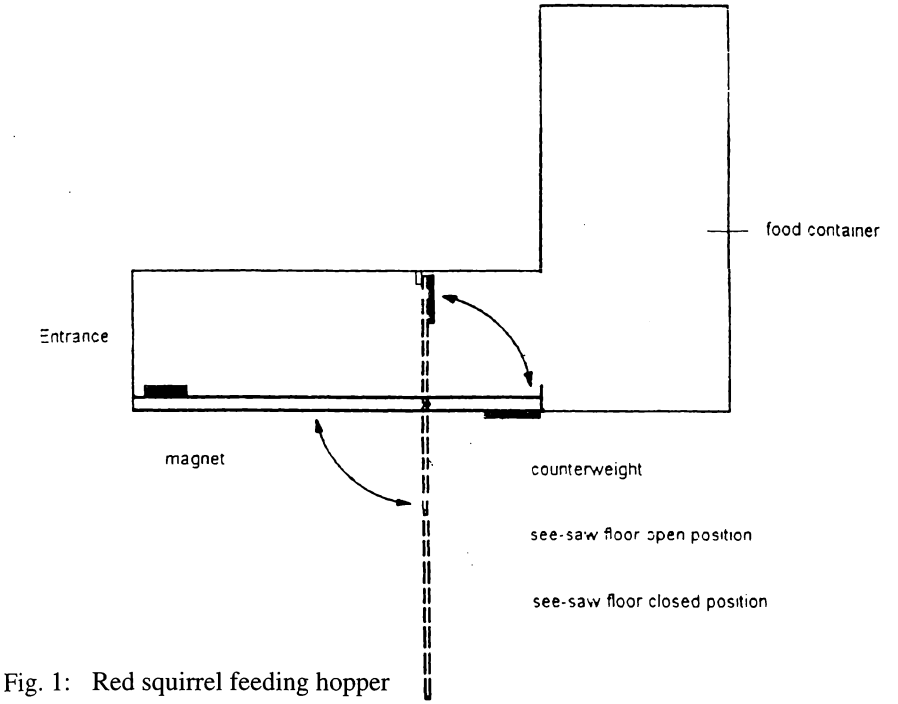

Fig. 1: Red squirrel feeding hopper

Several observational studies have been carried out on the behaviour of Grey squirrels at „red-only" hoppers. When food supplies are limiting there is a high motivation to learn to use the hoppers, some individuals were able to use the hoppers within a month of encountering them. A number of alterations that can be applied to hoppers of the existing design have been produced. Initial observations suggest that these altered hoppers are functioning effectively. A recent workshop bringing together the experience of many of the organisations utilising „red-only" hoppers has resulted in a new modified design of hopper. Further observational studies are in progress.

The use of „red-only" feed hoppers is a key part of both national and regional conservation programmes. However, no properly conducted field experimental study has assessed the population responses of Red squirrels to supplementary food supplied in „red-only" hoppers neither where Grey squirrels are present nor absent. Such studies are essential to justify the high expectations placed in the use of this tactic. The completion of this research is not purely a British priority, selective supplementary feeding may also become necessary in continental Europe in the future, given the spread of Grey squirrels in Italy.

Bauplan und Anwendung von „nur Eichhörnchen"-Futterspendern in Eichhörnchen-Schutzprogrammen in Großbritannien

Zusammenfassung

Die Anwendung von „nur Eichhörnchen"-Futterspendern ist ein wesentlicher Bestandteil regionaler und nationaler Artenschutzprogramme für die Erhaltung der Europäischen Eichhörnchen in Großbritannien. Das hier beschriebene Projekt zielt darauf ab die Reaktion von Eichhörnchen auf eine Zufütterung mittels dieser Behälter zu erforschen. Verschiedene Untersuchungsgebiete, die sich unter anderem durch Vorkommen oder Fehlen von Grauhörnchen (*Sciurus carolinensis*) unterscheiden stehen dabei im Vergleich. Solche Experimente sind nicht nur für die derzeitige Situation in Großbritannien relevant. Berücksichtigt man die gegenwärtige Ausbreitung nordamerikanischer Grauhörnchen in Italien, so kann das zusätzliche Füttern von Eichhörnchen vielleicht relativ bald eine wichtige Artenschutzmaßnahme im restlichen Europa sein.

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Plenary Discussion and Summary on Session 2: Feeding Ecology and Food Supplementation

PETER W.W. LURZ & JOHN GURNELL

The theme of this workshop session was the relationship between supplemental food and squirrel behaviour, body condition and population ecology and the possible use of supplementary feeding as a conservation tactic. To provide context for this theme John GURNELL opened the session by focusing on the effects of natural food abundance on squirrel numbers, as well as on the type of measures needed to quantify food abundance and squirrel demography. Different levels of detail and accuracy can be achieved according to sampling design and effort. Interactive effects of food and some environmental variables, such as weather, or the presence of other seed predators, influence the relationship between food and squirrel abundance. A related factor which affects the pattern of food availability is food caching by squirrels. Luc WAUTERS described how squirrels cache tree seeds and fungi. Seeds maybe larderhoarded (*Tamiasciurus* species) or scatterhoarded (*Sciurus* species; *Tamiasciurus* species in certain situations). Luc's paper demonstrated the importance of cached food and outlined ways in which food storage and retrieval might be quantified. Further studies on the costs and benefits of food caching to individuals in different types of habitat would be of interest. Do good

cachers retrieve more seed than poor cachers, and does this increase their fitness?

This led to Peter LURZ's detailed consideration of the topic central to the session: supplementary feeding studies on different species of squirrel. Two experimental studies on Red squirrels showed little impact of supplemental food. This appeared to be due to an abundance of natural food in one study, and possibly poor nutritional quality of the supplemental food (sunflower seeds and peanuts) in the other. Evidence of positive effects of supplementary feeding on squirrel survival and reproductive success come from studies on *Tamiasciurus* species and chipmunks. Peter highlighted a problem of data interpretation; temporary immigration into feeding areas could significantly affect local densities. Thus, there is a need to study space use of squirrels during feeding experiments. It was also pointed out by Henrik ANDÉN during discussion that it is important to design experiments carefully so that it is possible to evaluate failure. This should include a consideration of the independence of replicates and an assessment of the confounding effects of the abundance of natural foods.

The last two talks explored supplemental feeding as a conservation tactic with specific reference to the Red-Grey squirrel problem in Britain. Joanne LELLO reported on ongoing work by Craig SHUTTLEWORTH from Formby, Merseyside, England. Red squirrels in this coastal pine plantation are fed by the general public on a large scale; in a sense this is a 'natural experiment'. The results of Craig's studies so far indicate clear increases in squirrel density but also possible adverse effects of this high density on parasite loads and squirrel social behaviour (e.g. infanticide and cannibalism). Future results are eagerly awaited. Debby SMITH looked at one practical application of supplementary feeding of Red squirrels utilizing Red squirrel-only hoppers. She illustrated the techniques Grey squirrels used to gain access to food in the original design and outlined recent modifications to make the hoppers Grey squirrel proof. Debby stressed the need to fully test each design of hopper with Red and Grey squirrels. It is still not known whether supplementing the food of Red squirrels using these hoppers will enable Red squirrels to survive in the presence of Grey squirrels.

In open discussion, it was very clear that further supplementary feeding studies were required. These should really be longer than the normal 2 or 3 years, resulting from, for example, funding restrictions. The effects of removing the artificial food should also be assessed. Investigations on dispersal and home range size should accompany those on body condition, recruitment and mortality. Studies on Red and Grey squirrels in urban habitats would also be interesting. The problem of food quality (nutritional content, energy content, packaging) was raised several times. There was a need for many more food quality studies including those on captive animals.

The most lively discussion concerned the use of supplemental food hoppers as a conservation tactic. Many questions were addressed. Should food be distributed

centrally or dispersed in hoppers? What were the predation risks to squirrels around feeding hoppers? What other bird and mammal species took food from hoppers? What was the best type of food to use in hoppers? Do squirrels leave a scent on hoppers and does this affect their use by other individuals? There were no clear answers to any of these questions and it was evident that there was much scope for further research.

Plenumsdiskussion und Zusammenfassung der 2. Sitzung: Nahrungsökologie und zusätzliches Füttern - eine Zusammenfassung

Zusammenfassung

Die Themen dieser Diskussion beschäftigten sich vornehmlich mit den Zusammenhängen zwischen physischer Kondition, Sozialverhalten und Populationsökologie von Baumhörnchen. Zusatzfütterung als mögliches Hilfsmittel in den Schutzbemühungen um bedrohte Populationen von Eichhörnchen in Großbritannien wurde diskutiert. In Einzelfällen können Zusatzfütterungen offensichtlich die Dichten soweit erhöhen, daß negative Erscheinungen wie Infantizid und Kanibalismus ausgelöst werden. Eine Methodik um ausschließlich Eichhörnchen mit diesem zusätzlichen Futter zu erreichen, sowie der Gebrauch, die Nützlichkeit bzw. auch die Schädlichkeit verschiedener Futtertypen wurden ebenfalls diskutiert.
Langzeituntersuchungen bei gleichzeitiger Zufütterung fehlen noch und ihre Durchführung wurde dringend angeraten. Solche Untersuchungen sollten insbesondere die physische Kondition der Tiere, die Rekrutierung und die Mortalität beobachten. Gleichzeitig sollten Dismigration und die Streifgebietsgrößen Beachtung finden. Weiterhin wurde in diesem Zusammenhang die Notwendigkeit von weiteren Studien zur Qualität verschiedener Nahrungstypen im Hinblick auf Eichhörnchen aufgezeigt. Diese sollten dann insbesondere an Tieren unter Haltungsbedingungen durchgeführt werden.

Im Verlauf der Plenums-Diskussion wurden viele bisher ungeklärte Fragen aufgeworfen. So zum Beispiel ob Zusatzfutter besser zentral oder an mehreren Stellen dezentral im Gelände ausgebracht werden sollte, ob Futterstellen das Prädationsrisiko für die Hörnchen erhöhen oder welche andere Arten von diesen Futterstellen profitieren usw. Es wurde offensichtlich, daß hier ein weites Feld für zukünftige Untersuchungen besteht.

3. SQUIRREL ECOLOGY

3. Hörnchen Ökologie

Habitat use of Red squirrels (*Sciurus vulgaris* L.) in a mixed forest near the city of Halle/S., Germany

KRISTIN ZSCHEILE

European Red squirrels were studied in a suburban woodland (760 ha) in Central Germany. The area is highly frequented by the public for leisure activities. The 19 ha study plot was situated in a mixed forest with mature oak (*Quercus robur, Qu. petraea*), Scots pine (*Pinus sylvestris*) and beech (*Fagus sylvatica*) stands. It was bordered on two sides by main hiking trails.

For 1.5 years habitat use and demography of a Red squirrel population were investigated by Capture-Mark-Recapture method, visual observations of colour marked individuals and radio telemetry. Locations deriving from either of the three methods were combined and included in „multinuclear range analysis" using the software „Ranges IV" (KENWARD 1990). Drey site preferences were indicated by Ivlev´s Electivity Index $_{Ei}$ (IVLEV 1961 in KREBS 1989).

The resident squirrel abundance ranged from 0.31 to 0.47 ind./ha (MNA method, KREBS 1966) including the beech stands that were only occasionally used by the animals. Males had slightly larger home ranges than females:

	n	100% home ranges	70% core areas
males	5	5.6 ha (±2.5 ha)	1.1 ha (±0.5 ha)
females	4	4.4 ha (±3.1 ha)	0.7 ha (±0.3 ha)

The locations of the 70%-cores coincided with patches of high quality Scots pine. Five out of nine squirrels therefore had multinuclear core areas. During the course of the study 108 drey sites were mapped. Squirrels preferred evergreen pine canopies that provided shelter the whole-year-round ($_{Epine}$ = 0.57) whereas deciduous trees like oak and beech were avoided ($_{Eoak}$ = -0.36); $_{Ebeech}$ = -0.64). Large oak crowns faciliated movements over longer distances through an animal´s home range.

Central German squirrel populations exhibited comparably high body masses (this study: males on average: 380
g, females on average: 394
g). Urban influences did not affect the investigated population: Flight distances normally exceed 25 m, possibly due to permanent occurence of goshawks (Accipiter gentilis) in the study area. Furthermore, squirrels did not utilize anthropogenic food sources.

Habitatnutzung bei Eichhörnchen (*Sciurus vulgaris* L.) in einem Mischwald in der Nähe der Stadt Halle/S., Deutschland

Zusammenfassung

Habitatnutzung und Demographie einer Eichhörnchenpopulation wurden für eineinhalb Jahre in einem 760 ha großen stadtnahen Waldgebiet untersucht. Die Studienfläche umfaßte 19 ha und trug einen Mischwald aus Eichen (*Quercus robur, Q. petraea*), Kiefern (*Pinus sylvestris*) und Buchen (*Fagus sylvatica*), wovon die Kiefernbereiche durch die Hörnchen bevorzugt wurden. Obwohl die Eichhörnchen keine anthropogenen Nahrungsquellen nutzten, zeigten sie auffällig hohe Körpermassen.

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Space use in the European Red squirrel (*Sciurus vulgaris* L.) in a german montane mixed forest with varying resource availability

SIBYLLE MÜNCH

In species with promiscuitive or polygynuous breeding systems there are very often intersexually different space use systems. Males and females use the given resources differently and or use different behavioural strategies to secure their reproductive success (WAUTERS & DHONDT 1990, 1992). From January 1992 to October 1994 a total of 67 Red squirrels were captured on a 50 ha trapping grid in the Bavarian Forest National Park (GK 46 08 00 and 54 21 00) in Germany. 27 individuals (18 males, 9 females) were fitted with radio collars to study their space use system in a montane mixed forest (*Fagus sylvatica, Picea abies, Abies alba;* 1000m asl.).

On the basis of 100% Convex Polygones 80 home ranges (45 for males, 35 for females), representative for 2-month-periods were calculated using the computer program „Ranges IV" (KENWARD 1990). Each home range contained a minimum of 30 independent point fixes that were collected within 10-30 days. Care was taken to equally represent the whole activity period of the animals in the data set. Size and location of the individual home ranges as well as their changes over time were compared and checked for interactions with squirrel abundance, food availability and seasonally different activity behaviour.

Tab.1: Mean home range size (100% Minimum Convex Polygones) in ha (± S.D.) of Red squirrels, data combined for the period January 1992 to October 1994

	males			females		
	N	100% MCP	±S.D.	N	100%MCP	±S.D.
Jan/Feb	5	9,74	3,27	1	8,3	0
Mar/Apr	7	8,78	4,63	4	6,86	3,02
May/Jun	6	46,83	24,54	4	14,22	10,93
Jul/Aug	13	25,27	17,47	9	10,71	7,31
Sep/Oct	11	10,55	3,19	11	7,65	3,8
Nov/Dec	4	4,62	0,49	5	3,91	1,96

Combining the data for the three years (Tab.1) showed that males used significantly larger home ranges during the summer months (May to August) as compared to the rest of the year ($p<0.001$). For females the same tendency was observed but the differences between the seasons were not significant ($p=0,125$). Differences in home range size between sexes were significant only for the period Mai to August ($p<0.001$). In winter home range sizes were of the same size for both sexes and reached a minimum in November/December. In the colder season the energetic demands were assumed to be the same for males and females and both strongly reduced their daily phase of activity. The animals had to balance between potential energy gain through energy-consuming active foraging and energy-saving inactivity in their insulating drey. Foraging in winter took place in the vincinity of the drey and so for both sexes the area covered was small.

Apart from slight seasonal and individual effects female home ranges did not differ in size in between years even though food availability and squirrel abundance varied strongly (0.03-0.42 individuals ha^{-1}). The observed home range size obviously allowed female red squirrels in this habitat to find all the prerequisits necessary to survive and - in some cases - even to reproduce. Since there was no sexual dimorphism in the body masses of the squirrels, the home range size of the females was considered to energetically should be sufficient for male squirrels also. In contrast the home ranges of the males were not only larger than those of the females in the summer month ($p<0.001$) but also differed significantly in the size in between years ($p<0.05$). In respect to home range overlap the females intrasexually showed stronger exclusive tendencies than the males.

In conclusion female Red squirrels used the habitat by establishing a more or less stable distribution of individual home ranges, presumably determined by the limits of the long term changes in food availability and squirrel abundance. This „preset" size of a home range allowed it´s female owner - despite of later changes in food availability and female abundance - to have access to the resources needed to sustain itself or even to reproduce successfully. The interannual changes in the home range sizes of the males at the same time therefore could not be explained with differences in food availability or even territoriality as a consequence of changes in the abundance of males. Rather they were considered to be a reaction to changing numbers of females present. To increase it´s fitness in the sense of reproduction a male Red squirrel needs to have access to a certain number of females. In the present study this was achieved by adjusting home range size according to female abundance.

Raumnutzung beim Eichhörnchen (*Sciurus vulgaris* L.) in einem deutschen Bergmischwald mit veränderlicher Ressourcenverfügbarkeit

Zusammenfassung

Im Bergmischwald (*Picea abies, Abies alba, Fagus sylvatica*) des Nationalpark Bayerischer Wald wurden

während einer 3-jährigen Studie 67 Eichhörnchen gefangen. Von 27 dieser Individuen wurden per Telemetrie insgesamt 80 saisonale Streifgebiete ermittelt. Größe und Lage dieser Streifgebiete, deren geschlechtsspezifische Eigenschaften sowie deren saisonale und interannuelle Veränderungen wurden in Beziehung gesetzt zu der aktuellen Hörnchenabundanz, zur Nahrungsverfügbarkeit und zum saisonal unterschiedlichen Aktivitätsverhalten dieser Tierart. Für den Lebensraum Bergmischwald konnte dadurch ein saisonal unterschiedliches und geschlechtsspezifisches Raumnutzungssystem der Eichhörnchen nachgewiesen werden.

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The effect of pine martens *Martes martes* on the density of Red squirrels *Sciurus vulgaris* in Scotland - a survey

ELISABETH HALLIWELL

Anecdotal evidence has suggested that as the pine marten (*Martes martes*) expands its range in Scotland there is a decline in numbers of Red squirrels (*Sciurus vulgaris*). This study aims to determine the relative density of Red squirrels in several forests and relate it to the length of time martens have been present there.

The density of Red squirrels was assessed from counts of the number of freshly eaten cones on a 100 m transect (Grey squirrels *S. carolinensis* were not present in any of the areas surveyed). Between 10 and 30 stratified random transects were walked in Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) in each forest. At the end of

each transect a 10 m x10 m quadrat was used to determine various tree and ground cover habitat features. Cone availability was measured by assessing the cone density on 10 random trees on a scale of 0-4 and the number of cones on the ground was counted at intervals along the transect. Pine marten presence was determined by walking 2 km of track and searching for scats. A pine marten survey conducted in 1982 (VELANDER 1983) was used to group each of the forests in to one of three categories:

- no pine martens present - i.e. martens absent in this survey and in 1982,
- pine martens present for less than 10 years - i.e. martens present in this survey but absent in 1982,
- pine martens present for greater than 10 years - i.e. martens present in both this survey and in 1982.

There was a significant difference in the mean level of Red squirrel activity between the three groups of forests ($F_{2,15}$=8.01, P<0.006). Forests with no martens present had the highest mean number of eaten cones/100 m (x=19.1±6.3), compared with forests with martens present <10 years (x=8.7±2.8). Forests with martens present >10 years had the lowest activity of the 3 groups (x=1.5±0.6).

The difference in the feeding activity seen in the three groups of forests could not be explained by the availability of cones on the trees ($F_{2,15}$=1.3, P>0.1). The number of cones on the ground varied significantly between the three groups ($F_{2,15}$=4.62, P<0.04), but the forests with no martens present had the lowest number of cones. Of the remaining habitat variables measured no significant differences were found, although tree density showed a nearly significant difference ($F_{2,15}$=3.72, P<0.06). However, there was little difference between the forests with no martens present (x=12.0±2.7 trees/100 m^2) and those with martens present >10 years (x=14.0±1.6 trees/100 m^2). Forests with martens present <10 years had a higher mean density of trees (x=20.5±3.1 trees/100 m^2). A principle component analysis was used to describe different features of the overall forest structure. Plots of pairs of principle components with each forest shown according to the level of squirrel activity and then also according to the length of marten occupancy, revealed no pattern or grouping of the forests.

Red squirrel numbers therefore appear to be lower in forests where martens have been present the longest and analysis of habitat quality does not seem to explain the differences seen. However, other factors that may affect Red squirrel numbers still need to be incorporated into the analysis such as the total forest composition and the effect of climatic factors associated the east-west distribution of the forests surveyed. Therefore, it is not yet possible to say with certainty whether pine martens have had a significant impact on Red squirrel populations in Scotland.

Die Auswirkung des Baummarders (*Martes martes*) auf die Populationsdichte von Eichhörnchen in Schottland

Zusammenfassung

Es wird vermutet, daß sich die gegenwärtige Ausbreitung des Baummarders (*Martes martes*) in Schottland, negativ auf die Dichte und Verbreitung der Eichhörnchen (*Sciurus vulgaris*) auswirkt. Die vorliegende Arbeit untersucht die relative Populationsdichte von Eichhörnchen in einigen Waldgebieten in Bezug auf die Dauer der Besiedlung durch Baummarder.

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4. MORPHOLOGY

4. Morphologie

The colour phases of the European Red squirrel (*Sciurus vulgaris*)

HERBERT WILTAFSKY

The coat colour of the polymorphic European Red squirrel *Sciurus vulgaris* varies from red to black. Surveys from large populations show that the different coloration types are not distinct but the different morphs gradually range from extremely red speciemens to completely black ones at the other end of the scale (WILTAFSKY 1973, 1978). These findings are supported by measurements that were made with an electric-remission-photometer used on the whole range of available morph types (Fig. 1).

A collection of squirrels originating from the German „Allgäu"-region covering parts of Bavaria and Württembergia was measured. The data confirmed that there are no differences in the coloration of the back between black and brown individuals as measured by the above method. In contrast a combination of the color traits of the feet and the coloration of the tail were consistent and representative enough to allow a classification of three main color morph types:

1. red morph with red feet and red tail
2. brown morph with red feet and black tail
3. black morph with black feet and black tail

Breeding experiments carried out over more than 20 years showed that red feet are a dominant, black feet are a recessive trait. The heredity of the colour of the tail proofed to be much more complicated and seemed to be controlled by the interaction of several different genes (WILTAFSKY 1977).

Die Farbvariationen des Europäischen Eichhörnchens (*Sciurus vulgaris*)

Zusammenfassung

Die Fellfarbe des polymorphen Eichhörnchens kann vom hellsten Rot bis zum tiefsten Schwarz variieren. Die Fellfarbe wurde an Museumsmaterial aus dem Allgäu mittels eines elektrischen Remissionsphotometers bestimmt. Braune und schwarze Exemplare waren durch Messungen der Farbe des Rückenfells nicht zu unterscheiden. Eine Betrachtung der Farbmerkmale der Füße in Kombination mit der Färbung des Schwanzes, erlaubte jedoch eine Klassifizierung von drei Hauptfarbtypen bei Eichhörnchen aus dieser Region.

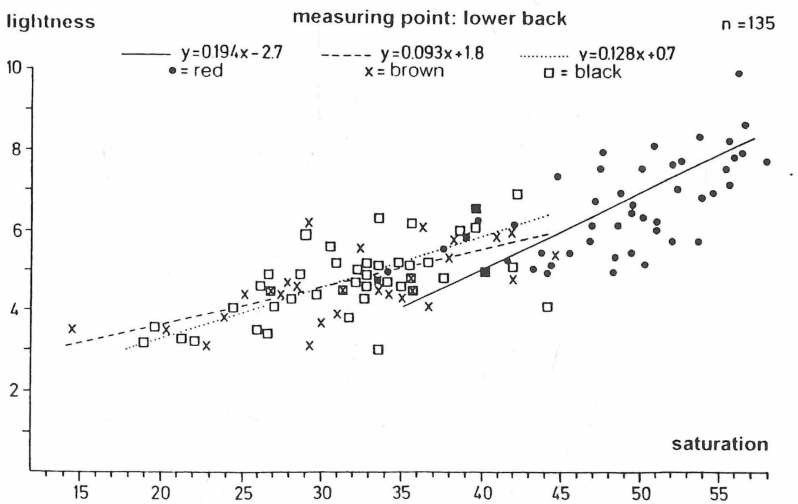

Fig. 1: Distribution of different color morph types as revealed by electric-remission-photometer

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Investigations on the morphology and histology of the integument of the European Red squirrel *Sciurus vulgaris* L.

DANIELA FRAEFEL

The Red squirrel *Sciurus vulgaris* shows adaptations in its body for the arboreal way of life. Investigations on morphology and histology of the integument from different parts of the body were carried out to look for such adaptations and relate them to their functions.

The Red squirrel has tactile hairs on the head, on the forelimbs and in the region of the breast and abdomen, which can be divided into different groups of tactile hairs. Except for the Vibrissae mystaciales and Vibrissae anconeales, the number of the tactile hairs varies from one individual to the other. This shows an intraspecific variability.

In the region of the chin on each side of the head, there is an accumulation of apocrine glands. Its the first time that apocrine glands were found in the Red squirrel; they are present in males and females. The secret could be used for face wiping. Besides these apocrine glands there are eccrine glands in all footpads. The Red squirrel has relatively long hindfeet in comparison to the forefeet. When the squirrels move on horizontal surfaces only the digits and the footpads are set down. Long hindfeet increase stability while climbing stems and sitting places. Squirrels use their long claws when climbing vertical surfaces. In the region of the tarsal pads there are areas with the poorly visible or even on the surface not visible hairs. In the largest area there are roots of hairs with clearly enlarged sebeacous glands. The secretion of these sebeacous glands could mark the surface of the frequently visited feeding places.

The forefeet are adapted to manipulate for example food. The carpal pads with the reduced first digit are in opposition to the second to fifth digit. Both carpal pads contain muscles and cartilage. They are an abutment against the force of gripping digits.

Morphologische und histologische Untersuchungen am Integument des Eichhörnchens *Sciurus vulgaris* L.

Zusammenfassung

Das baumlebende Eichhörnchen *Sciurus vulgaris* weist in seinem Körperbau Anpassungen an die arboreale Lebensweise auf. In der vorliegenden Arbeit wurde versucht, anhand von grobmorphologischen und histologischen Untersuchungen solche Adaptionen am Integument verschiedener Körperregionen zu finden und funktionell zu interpretieren.

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5. CONSERVATION

5. Schutz

Conservation of the Red squirrel (*Sciurus vulgaris*) in Britain - a genetic approach

ELISABETH BARRATT & JOHN GURNELL

Within recent history, Red squirrel (*Sciurus vulgaris*) populations in Britain have become fragmented as a result of habitat loss and competition with the introduced Grey squirrel (*S. carolinensis*). This species is now under genuine threat of extinction in the UK and by the year 2000 there will be very few places in Central and Southern England and Wales where they will still occur.

A reintroduction programme was started in Thedford Forest as a joint initiative between English Nature (under the Species Recovery Programme), Forest Enterprise (Thedford District), the Forestry Authority and Queen Mary & Westfield College. The study is being carried out in 1800 ha of forest designated as a Red Squirrel Reserve and includes the removal of Grey squirrels and supplementary feeding of Reds.

In order to identify source populations for the reintroduction programme, this project aims to study genetic variability within and among fragmented populations in Britain. A preliminary study analysed sequence data from the mitochondrial DNA control region of 61 Red squirrels from 13 populations. Analysis of this data revealed geographic segregation of mtDNA genotypes among populations and an overall low level of sequence divergence within and among populations. This study has now been expanded to include additional population samples and we are currently developing Red squirrel microsatellite primers for a comparative study of nuclear DNA variation. These results, the use of nuclear and mitochondrial DNA analysis, and the implications for management programmes will be discussed.

Der Schutz der Eichhörnchen (*Sciurus vulgaris*) in Großbritannien aus genetischer Sicht

Zusammenfassung

Im Thetford Forest, East Anglia, England wurde in einem 1800 ha großen Schutzgebiet ein Wiedereinbürgerungs-Projekt für Eichhörnchen begonnen. Die hier beschriebene Studie versucht anhand der genetischen Variation in den verschiedenen voneinander isolierten Populationen von Eichhörnchen in Großbritannien, geeignete Individuen für das Projekt zu finden. Erste Ergebnisse über 61 Eichhörnchen aus 13 verschiedenen Populationen zeigten geographische Variation zwischen den Populationen in der Kontrollregion der mtDNA. Die Sequenzunterschiede waren jedoch sowohl innerhalb als auch zwischen den verschiedenen Populationen insgesamt gering.

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Application of Population Viability Analysis to *Sciurus vulgaris*

JILL M. BIRCH

Population Viability Analysis can be used to quantify the risks facing populations under threat and to establish acceptable risk management within the constraints of finite resources. The present study explores the feasibility of such an approach for *Sciurus vulgaris* which faces increased risk of local extinction in the UK through a combination of habitat loss and/or habitat fragmentation and progressive range extension by *Sciurus carolinensis*.

Stochastic models, incorporating both demographic and environmental stochasticity, were constructed using the software package RAMAS/age (FERSON et al. 1990). This is a discrete time model for single populations which uses a modified Leslie matrix approach to compute abundance in the next time-step. The program employs a Monte Carlo algorithm to simulate population trajectories over a defined period using a catalogue of life-history parameters entered by the operator. Replicate simulations yield a range of outcomes from which final mean abundance and risk of extinction can be computed.

A literature search for the life-history parameters required by the model, revealed a scarcity of long-term data sets. This renders both the determination of mean parameter values and their coefficients of variation (key components for determining environmental stochasticity in the model) particularly difficult. Furthermore, the best available estimates of mean parameters, when assembled in a Leslie Matrix, yielded a finite rate of increase of less than 1. Since over long periods of time a population at equilibrium might be expected to show a of 1, parameters were adjusted to yield a just positive rate of instantaneous increase. The resulting survival rates of adults (60%) and juveniles (post-weaning, 41%) are inevitably slightly higher than can be supported generally in the literature.

Determining the magnitude of variation in survival and fecundity is a fundamental problem in attempting to model environmental stochasticity. The large coefficients of variation (c.v. juvenile survival=0.89, c.v. fecundity=0.99, c.v. adult survival=0.4) reported either for *S. vulgaris* or where absent, for *S. carolinensis* (J. GURNELL, unpubl.), result in projected mean abundance becoming impossible to predict with confidence after just two years. They also result in greatly increased risks of extinction

and confound attempts to identify Minimum Viable Population (MVP) sizes. The latter were only obtainable for periods of 25 years when variation in fecundity and juvenile survival was approximately halved. The extent of correlation between parameters is also uncertain and can exacerbate the effects of variation on extinction risk.

The results of this preliminary exercise highlight a number of points with regard to modelling Red squirrel populations. Variation in mean parameters exerts considerable influence on estimated extinction risks and hence MVP estimates. Long term population studies are needed to determine mean parameters, the degree of correlation and critically, the extent of year-to-year variation encountered. Sensitivity analyses for the models constructed here suggest that survival and in particular, juvenile survival, needs careful estimation. Until these parameters can be better constrained, the results of any modelling exercise should be treated with caution. Furthermore, closed, single population models as used here, are likely to be inappropriate where habitat connectivity enables migration between patches. Since even modest amounts of immigration can result in greatly improved extinction risks, metapopulation models are likely to offer greater potential in the future.

Die Anwendung der „Population Viability Analysis" auf *Sciurus vulgaris*

Zusammenfassung

Population Viability Analysis (PVA) wird benutzt um die Risiken, denen bedrohte Populationen ausgesetzt sind, zu quantifizieren. Die Ergebnisse können dann helfen, innerhalb der Grenzen der verfügbaren wirtschaftlichen Mittel, sinnvolle Richtlinen für ein Risikomanagement zu entwerfen. Die vorliegende Studie prüft die Nützlichkeit dieser Methode für Populationen von *Sciurus vulgaris* in Großbritannien, welche durch Verlust und Fragmentierung des Habitats und durch die Ausbreitung von *Sciurus carolinensis* lokal vom Aussterben bedroht sind.

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What are the chances that the golden squirrel (*Sciurus anomalus*) will survive under the new regime?

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The Persian squirrel *Sciurus* (*Tenes*) *anomalus* Gmelin 1778 is found in south-eastern Europe and western Asia. The golden squirrel (*Sciurus anomalus syriacus* Ehrenberg 1828), a subspecies of the Persian squirrel, is distributed in Syria, Lebanon and Israel. The prehistoric picture shows the presence of Persian squirrels in Israel. Those squirrels, due to severe climatic changes, retreated to the northern part of the country - the Galilee mountains and Mt. Hermon in the Golan. They had lived in the Upper Galilee forests until the forests' destruction by human actions such as burning or cutting the woods, overgrazing, and exterminating the antelopes that shaped the forests. The squirrels had moved into the remaining forests of the Galilee that were kept alive because of the scarcity of the settlements around them. However, with time, even those squirrels disappeared. The only population left in Israel is the one on Mt. Hermon. Between the squirrels' forested habitat on Mt. Hermon and the remaining forests in the Galilee there is an unwooded barrier. Before 1967 the Hermon was almost empty of humans. Aside from temporary settlements during the summer, in which farmers from Lebanon cultivated small parts of the mountain, only few trespassers invaded the squirrels' land. After the war of 1967 between Israel and Syria, the Israeli army controlled 7% of the southern part of Mt. Hermon. The mountain on the Israeli part was declared a nature reserve and the plants and animals, which included the squirrels, were protected. Yet, the battle among the Israelis and their neighbours goes on. The Israelian government is eager to come to peace with the neighbouring countries and is willing to exchange some land for peace. Part of this land includes the squirrels' habitat which would then shift hands to Syria. For the welfare of the squirrels this action is very worrying.

A coworker in Syria reports that their squirrel population has decreased dramatically over the past several years. The situation in Lebanon is not better. The latest reports from Lebanon state that no squirrels have been seen since the civil war and the war with Israel. In both places the species is undoubtedly in danger of extinction for the reason of intensive hunting activities. The diurnal golden squirrels make excellent targets and modern vehicles easily permit access to the squirrels' habitat.

Since its establishment in 1948 vast parts of Israel have been declared nature reserves. The remaining old trees in forests were taken care of and the eradicated parts were refo-

rested. The Galilee appears to be an ideal equivalent to the Mt. Hermon habitat for the following reasons: The forests in the Galilee grow on mountains of 1000-2000 m height, while the squirrels' habitat in the Hermon is at 1100 m. The Mediterranean climate, cold and rainy in the winter and dry and hot in the summer, is the same in the Galilee and the Hermon. The nature reserves in the Galilee are monitored by rangers. The forests have abundant oak trees so the animals can easily move through the canopy without being exposed to predators. There are many hollow trees that the squirrels can seek shelter in and use for nesting.

So what are the chances that the squirrels will survive if the Hermon would change hands? Close to zero if they stay in their present habitat. My suggested solution to rescue the squirrels is to reintroduce them into their former habitat in the Galilee.

Welche Überlebenschancen hat das Kaukasische Eichhörnchen (*Sciurus anomalus*) unter einem neuen politischem Regime?

Zusammenfassung

Die historische Verbreitung dieser Hörnchenart und deren einzige heute noch in Israel existierende Population werden beschrieben bzw. deren Überlebenschancen auf dem Hintergrund der politischen Lage im Nahen Osten diskutiert. Eine mögliche Wiedereinbürgerung von Kaukasischen Eichhörnchen im Galilee wird vorgeschlagen.

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Red squirrels (*Sciurus vulgaris* L.) in Clocaenog Forest

SARAH CARTMEL

Clocaenog Forest is situated in North Wales and is probably the last stronghold of the Red squirrel *Sciurus vulgaris* in Wales. The forest is a commercial plantation (4,000 ha) consisting mainly of Sitka spruce (*Picea sitchensis*) and Norway spruce (*Picea abies*) with clumps of Scots Pine (*Pinus sylvestris*) and Japanese larch (*Larix kaempferi*). A project was set up in 1992 by the Forest Enterprise and the Countryside Council for Wales to study the population of Red and Grey squirrels in the forest and to produce a management plan for 2,000 ha of the forest designated a Red squirrel reserve.

During the first year observation transects were used to indicate the habitat type that the Red squirrels were occupying, unfortunately there was a bias in the results towards tree species in which the squirrels were more visible (Japanese larch and Scots pine).

Cone transects were set up in November '92 and have been counted once a month throughout the 3 year study. They show clearly the tree species in which the squirrels have been feeding - predominantly Scots pine in all years.

In November 1993 a trapping programme began, success was low until June 1994 and by the autumn there was a sufficient number of radio collared Red squirrels for radio tracking to begin. In total 30 Red and 49 Grey squirrels have been caught in 14 trapping sessions; 22 Red squirrels have been radio collared and on average 5 Red squirrels were radio tracked each month. The radio tracking data for winter 94/95 was analysed using Ranges IV (Kenward, ITE, Wareham, Dorset, UK). Red squirrels had an average home range of 5.85 ha and a core range of 0.99 ha, Grey squirrels tended to have smaller ranges: average home range 3.46 ha and a core range of 0.23 ha. The habitat content of the ranges was similar between squirrel species and for Red squirrels the greater the percentage of Scots pine within the home and core range the smaller the range size, suggesting the Red squirrels favoured Scots pine. A high percentage of radio collared Red squirrels were predated during early summer '95, most were males who tend to move around a lot at this time of year and so are more vulnerable to predation, however this was also a time of low food availability - the squirrels were spending more time foraging on the ground and this may have been a factor in their predation.

The conclusions reached so far:

1. Both Red and Grey squirrels are present in the forest at low densities and are breeding.
2. Both species feed on the same tree species, favouring Scots pine and Norway spruce, and will generally avoid each other.
3. The population size of Red squirrels is probably limited by the amount of Scots pine in the forest.
4. More information is required on the breeding success of Grey squirrels and their effect on the Red squirrels.

Eichhörnchen (*Sciurus vulgaris* L.) im Clocaenog Waldgebiet

Zusammenfassung

Clogaenog ist ein Waldgebiet im Norden von Wales, welches wahrscheinlich die letzte große Population von Eichhörnchen in Wales beherbergt. Der Wald besteht hauptsächlich aus Sitkafichte (*Picea sitchensis*) und Rotfichte (*Picea abies*) sowie kleineren Anpflanzungen von Kiefern (*Pinus sylvestris*) und Lärchen (*Larix kaempferi*). 2000 ha des Waldes wurden 1992 als Schutzgebiet für Eichhörnchen ausgewiesen. Erste Resultate zeigen, daß sowohl Eichhörnchen als auch Grauhörnchen (*Sciurus carolinensis*) die Samen der gleichen Baumarten bevorzugen (Waldkiefer und Rotfichte) und daß die Populationsdichte der Eichhörnchen von der Ausdehnung (ha) der vorhanden Kiefernanpflanzungen beeinflußt wird.

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Progress of Red squirrel conservation in the NW of England - NPI Red Alert North West -

LUCY WARD

NPI Red Alert North West is a Red squirrel conservation partnership that consists of over 120 organisations and individuals, whose aim it is to ensure the survival of the remaining Red squirrel populations in the North West of England. The main areas where only Red squirrels exist is in the North and West of Cumbria, and the Sefton Coast in Merseyside. An interface zone, where the two species are currently competing directly for food resources covers much of the rest of Cumbria and North Lancashire, as well as West Lancashire adjacent to Merseyside.

1. Local Action

Local groups of NPI Red Alert NW are being set up throughout the area where Red squirrels are still in existence (see map). Where they have been set up they consist of local landowners, woodland owners, gamekeepers and local volunteers.

Where appropriate the short term priorities that are being encouraged in these local groups are comprehensive Grey squirrel control, supplementary feeding of the Red squirrels and the locating and monitoring of the Red squirrel populations in the woodlands. Long term priorities include consideration of woodland composition and in Red only areas, contingency plans for Grey squirrel expansion or other Red squirrel threats.

Additionally there is support by Local Authorities. As a result supplementary planning guidance notes and hazard maps are being drafted, to be absorbed into their land management and planning processes.

2. Conservation prescriptions

Supplementary feeding of Red squirrels in the interface zone of the two species and in other areas during poor seed years is being encouraged. Grey squirrel control within the interface area of the two species is also being undertaken in much of the area, especially through the liaison of local group members.

A habitat management leaflet that gives broad advice to owners of woodlands where Red squirrels are still present, and are interested in managing their woodland in a way to favour Red squirrels has been written. The leaflet differentiates between different types of woodland. Even so we are aware that altering the long term structure of wood-

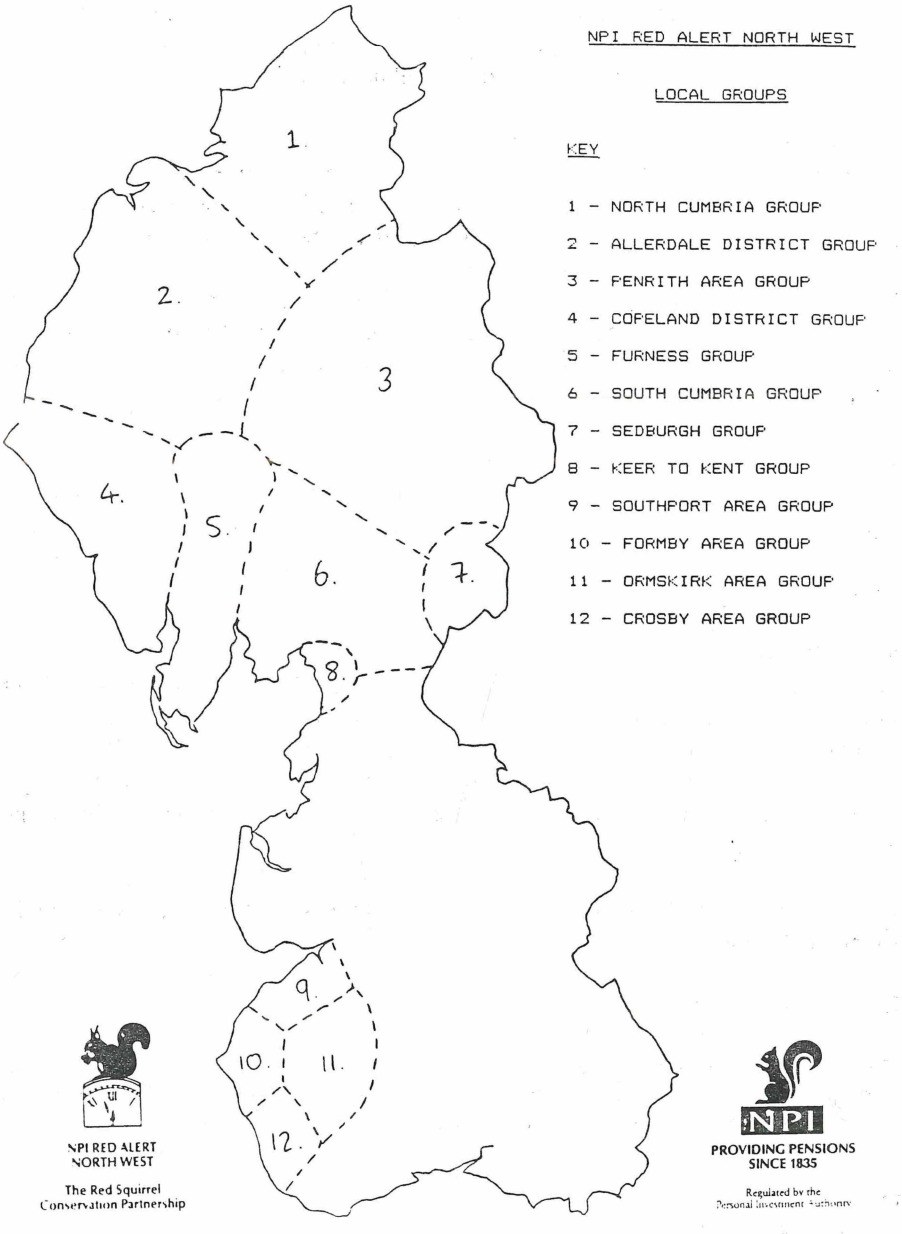

Fig. 1: Local groups of the „NPI Red Alert North West“ - Programme

lands where Red squirrels are not likely to be present in the long term is not acceptable. The Project Officers are often consulted on controversial WGS (Woodland Grant Scheme) applications where prime Red squirrel habitat is involved.

3. Monitoring squirrel populations

Squirrel Recording Forms are being used to record presence of Red and Grey squirrels which aids the project and local groups in targetting action. These records will soon be put into the database „RECORDER" and a report will be published annually.

At the more detailed level of individual woodland surveys, monthly walks and hair tube surveys are taking place within the local groups. By commencing these as soon as possible the information should prove to be a valuable evaluation tool in establishing whether conservation measures in these woodlands are successful.

4. Awareness

Raising awareness continues to play an essential role in NPI Red Alert NW. „Red Squirrel Week" was even bigger this year, with many events taking place all over the North West. An estimated 1400 people came to the events in the region and over £800 has been raised.

5. The future

Finally, our objectives for the coming year are to continue to support and develop the local groups to ensure widespread Red squirrel conservation in the region. We will continue the monitoring and surveying programme, and additionally work towards the collation and presentation of the data collected. A review of the regional strategy for evaluation purposes and to take on board the recently drafted UK strategy is also underway.

Fortschritte des Eichhörnchenschutzes im Nordwesten von England - NPI Red Alert North West -

Zusammenfassung

NPI Red Alert North West ist eine Partnerschaft von über 120 Organisationen und Privatpersonen, deren Ziel es ist, das Überleben der letzten Eichhörnchenpopulationen im Nordwesten Englands zu sichern. Die Struktur, die Aktivitäten und die Ziele von Red Alert werden in fünf Punkten beschrieben.

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Modelling the distribution of Red and Grey squirrels in U.K.: trials with East Anglia and Scotland

STEPHEN P. RUSHTON, PETER J. GARSON & PETER W. W. LURZ

There is some detailed data on the past distributions of Red and Grey squirrels (*Sciurus vulgaris* and *S. carolinensis*) in the U.K., and a wealth of records since about 1990 for both northern England and southern Scotland, thanks to recent conservation initiatives for the native species in this area. High-resolution habitat mapping data is also available from satellite images and other sources. In order to predict how things will change in future for Red and Grey squirrels in U.K., a computer model is needed that simulates the behaviour of populations of both species, from given starting points and over long periods of years, on a map of the real landscape.

We have developed a system of this kind, using a Geographical Information System (GIS) of software called GRASS (WESTERVELT et al. 1990). The GIS contains a detailed map of all broadleaf woodland, conifer forest and urban habitat patches for the area being investigated. All other habitats are regarded as being relatively hostile to squirrels, but in the model they are allowed to disperse between patches of the remaining three habitat types. The GIS also contains data on the number of squirrels occupying each patch of habitat at any time.

The number of squirrels in each habitat patch at any time is controlled by population biology sub-models (one for each species), which are based on real processes like reproduction, survival and dispersal, with parameter values limited to a realistic range by reference to the literature (e.g. GURNELL 1987, WAUTERS & DHONDT 1992, LURZ et al. 1995). For instance, dispersals are triggered when a patch of habitat becomes saturated with squirrels as a result of immigrations and births together exceeding mortalities there. The competitive interaction between Red and Grey squirrels in patches where they occur together is also sub-modelled by imposing a reduction in both the maximum density and breeding capacity of reds in proportion to the local density of Greys.

The biggest problem with models of this kind is to make them behave plausibly in relation to time: in other words they require calibration. We have used detailed published data on the spread of Greys and contraction of reds in East Anglia during 1966-1981 (REYNOLDS 1985), to produce a version of the model that mimics what actually happened. To do this we ran the model many times, using different values for parameters such as litter size and survival rates, in an effort to maximise the fit. The best-fit version of our model does not predict the total extinction of the Red squirrel from East Anglia, where they still occur in 1995, even if it is run for many more decades.

This version of the model was then applied to the problem of predicting future Red and Grey squirrel distributions in Scotland**. Our principle sources of real data on the distributions were the 1980 records from the Forestry Commission of presence or absence of either species in each 10 x 10 km grid square in which it owned forest, and the Scottish Natural Heritage database of all records up to 1994, which we scaled up to 10 x 10 km squares for comparisons. We submitted the 1980 data to our model as a starting point and then ran it until 1994. The real and predicted distributions of reds and Greys are reasonably similar, so we continued to run the model until 2025. By this time the predicted distribution of the Grey squirrel in Scotland extends to the coast in the southwest, and throughout an area to the north of the central lowlands surrounding Glasgow and Edinburgh, for a distance of about 100 km. Despite this, the model also predicts the persistence of the Red squirrel in most areas. As it is set up, this is because the model only allows Greys to occupy a proportion of large coniferous habitat patches, which are common in Scotland.

We are now in a position to predict the likely effects of conservation action for the Red squirrel, in forms such as Grey control and habitat management, in their areas of present or future overlap in U.K. In addition, by using existing data on the extent of bark-stripping damage by Greys, we should be able to estimate the potential cost, in terms of lost timber revenues, of the unhindered spread of Greys in U.K.

** This work was undertaken as a contract for Scottish Natural Heritage.

Die Verbreitung von Eichhörnchen und Grauhörnchen in Großbritannien kann mit Hilfe von Computermodellen simuliert werden: Versuche mit Daten von East Anglia und Schottland

Zusammenfassung

Ein Computermodell, welches das Verhalten und die Populationsdynamik von Eichhörnchen und Grauhörnchen simuliert wird benötigt um vorherzusagen, wie Veränderungen in Habitatstruktur und Waldbewirtschaftung das zukünftige Schicksal des bedrohten Eichhörnches in Großbritannien beeinflussen. Das Computermodell, welches in Verbindung mit einem Geographischen Informations System (GIS), biologische Prozesse wie Reproduktion, Habitatnutzung und räumliche Verteilung der Hörnchenarten simuliert, wird in vorliegender Arbeit beschrieben und mit Verbreitungsdaten aus East Anglia und Schottland getestet.

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6. Varied Topics

6. Verschiedene Themen

The Introduction of Red Squirrels into Monsanto Forestry Park, Lisbon

MARINA PACHECO

Squirrels were numerous, especially in the north of Portugal until the 16th century. During the 16th century intensive agriculture and land development fragmented the squirrel's natural habitat, and led to its extinction.

Since then at least three reintroductions have been attempted in Portugal over the last 150 years (ANTUNES 1985, MATHIAS & PETRUCCI-FONSECA 1992). The first attempt occurred around the middle of last century in Sintra (district of Lisbon), probably with squirrels from Central Europe. The second introduction, with squirrels that were probably from England, consisted of two introduction attempts between 1872 and 1900, in Belas (Lisbon district), these squirrels survived for more than 30 years. The third attempt was about 50 years ago in Fornos de Algoderes (Viseu district), with squirrels from Belgium (ANTUNES 1985, MATHIAS & PETRUCCI-FONSECA 1992). None of these introduced populations still exist today.

Over the last few years, however, naturally occurring populations of squirrels have been re-establishing themselves in the North of Portugal, particularly in Peneda-Gerês National Nature Reserve. These squirrels have migrated into Portugal from Spain (MATHIAS & PETRUCCI-FONSECA 1992). With the natural return of squirrels to Portugal, it was felt that now was an opportune moment to attempt the introduction of a group of squirrels into Monsanto Forestry Park, Lisbon.

Monsanto is the main park of Lisbon and is situated on the outskirts of the city. It covers an area of about 1000 ha. The whole park is surrounded by urban developments. The park is crossed by many roads. Inside the park are a number of buildings. The dominant tree species of Monsanto are: Stone Pine (Pinus pinea), Aleppo Pine (*P. halepensis*), Cypress (*Cupressus lusitanica*), Cork Oak (*Quercus suber*), Holly oak (*Q. ilex*) and Eucalyptus (*Eucalyptus globulis* lab.). In addition there are a few Pedunculate oaks (*Quercus robur*).
In April 1993, 15 squirrels were released into Monsanto. The squirrels chosen for this introduction came from Spain in the Pinarejo Mountain in the municipality of San

Martín de Valdglesias and in the surrounding mountains of Robledo de Chavela y Valdemaqueda, in the south east region of the autonomous community of Madrid. The squirrels have been introduced for three reasons: environmental education, conservation and recreation.

The project has two main aims. The first is to learn as much as possible about the ecology of the squirrel in Portugal. The second is to assess the success of the introduction of the squirrels into Monsanto Forestry Park by comparing them to the naturally occurring population of Peneda-Gerês. At the same time various management techniques will be tried and their effects monitored with the intention of developing an optimal habitat for the squirrels in Monsanto. Particular interest is paid to the diet of the squirrels as they do not have Beech or Hazel in Monsanto. Also the effects of the relatively mild Mediterranean climate on population fluctuations and the activity budget will be investigated.

Die Wiedereinbügerung von Eichhörnchen in den Monsanto Forestry Park, Lissabon, Portugal

Zusammenfassung

Eichhörnchen waren bis zum 16. Jahrhundert in Portugal sehr häufig. Die wirtschaftliche Entwicklung und die Intensivierung Landwirtschaft sowie die daraus folgende Fragmentierung des Lebensraumes hat jedoch zum Aussterben dieser Hörnchenart in Portugal geführt. Die Wiedereinbürgerung von 15 Eichhörnchen im Wald Park Monsanto im April 1993 und die Ziele und Forschungthemen dieses Projektes werden hier beschrieben.

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The Red squirrel (*Sciurus vulgaris* L.) in the city of Rome, Italy

MAURO CRISTALDI, ALESSANDRA SARTORETTI & BRUNO CIGNINI

In the central-northern sector of the city of Rome there is a large planted area called the Villa Ada and the Monte Antenne district. 66 ha of a total of 150 ha of planted area are open to the public since 1954. The area is completely surrounded by streets which are lined with multi-storey buildings established in the 1960s. In the planted area over 20 different species of trees both native and introduced can be found. The tree canopy covers up to 95% of the ground and most of the trees are over 50 years old.

The wildlife includes many species of birds and mammals including *Sciurus vulgaris* and the introduced *Tamias sibiricus*. The origin of this Red squirrel metapopulation is still under investigation; it seems likely that it traces back to the last century. On the basis of morphological characteristics it appears to be the subspecies *italicus*. Field observations revealed that the colour morphs of this population are ranging from an uniform ochraceous red to a dark brown head, body and tail, with sometimes an intermixture of greyish or grizzeled hair. The characteristic ear tufts have been noticed from autumn to spring. The squirrels main food type in the Villa Ada and the Monte Antenne district are pine seeds. Preferred are in order of importance the seeds of *Pinus halepensis, P. pineaster, P. pinea*. Acorns (mainly *Quercus ilex*, second in numbers to pines), fig (*Ficus carica*) and berries (*Rubus ulmifolius* and *Rosa canina*) provide good additional foods.

Potential squirrel predators that are present in the park are *Mustela nivalis, Strix aluco* and *Vulpes vulpes*. *Rattus rattus*, which also feeds on pine cones, is a possible competitor of the Red squirrel for food. Crows (*Corvus corone cornix*) and dogs also seem to disturb the squirrels by attacking them.

The presence of two other very small isolated Red squirrel populations within the city of Rome is know only from two neighbouring urban parks which are the Villa Borghese and Villa Strohl-Fern. Two years ago there were also recordings from the Villa Medici. Attempts to introduce the Grey squirrel *Sciurus carolinensis* into the Villa Celimontana in 1982 fortunately failed and the species luckily did not become established within the city of Rome like it did in the northern parts of Italy.

Altogether the metapopulation of the Red squirrels living in the parks of Rome is estimated to consist of about 100 individuals. Fragmentation of the habitat especially in the urbanized area enhances inbreeding phenomena, and increases pathogens also through vectors. Finally a potential pressure of rodenticides and of urban xenobiotics could be a factor of decline for these urban populations in the middle-long terms.

To preserve them in the long run a linking of these parks to other surrounding wooded areas with squirrel presence is advisable. The metapopulation living in the outskirts of the city is still numerous.This effort would include a restoring of pine areas that could function as ecological corridors which should be done according to the landscape characteristics of the city. Connecting corridors are still possible between the north east surroundings of the city and the north west side through the arboreal areas of the city because these areas are located quite nearby naturally growing woods and bushes on the hilly and low mountain orography of this part of the region. The permanent presence of *Sciurus vulgaris* has been reported there and so these areas could act as potential sources for Red squirrels to immigrate via the established corridors into the otherwise isolated urban subpopulations within the city of Rome.

Das Eichhörnchen (*Sciurus vulgaris* L.) im Stadtgebiet von Rom, Italien

Zusammenfassung

Im Monte Antenne Bezirk der Stadt Rom befindet sich die sogenannte Villa Ada. Es handelt sich dabei um ein bewaldetes Grundstück, welches ca. 150 ha umfaßt. Es ist sehr baumartenreich, bietet Lebensraum für viele Vogel- und Säugetierarten und beherbergt unter anderem eine Population von *Sciurus vulgaris* und eine Population von *Tamias sibiricus*. In zwei weiteren Parks der Stadt existieren ebenfalls kleine isolierte Vorkommen von *Sciurus vulgaris*. Maßnahmen zu deren Schutz wie z.B. Vernetzung der Parks untereinander bzw. mit nahegelegenen Waldgebieten über Baumreihen, die als Korridore dienen können, werden vorgeschlagen.

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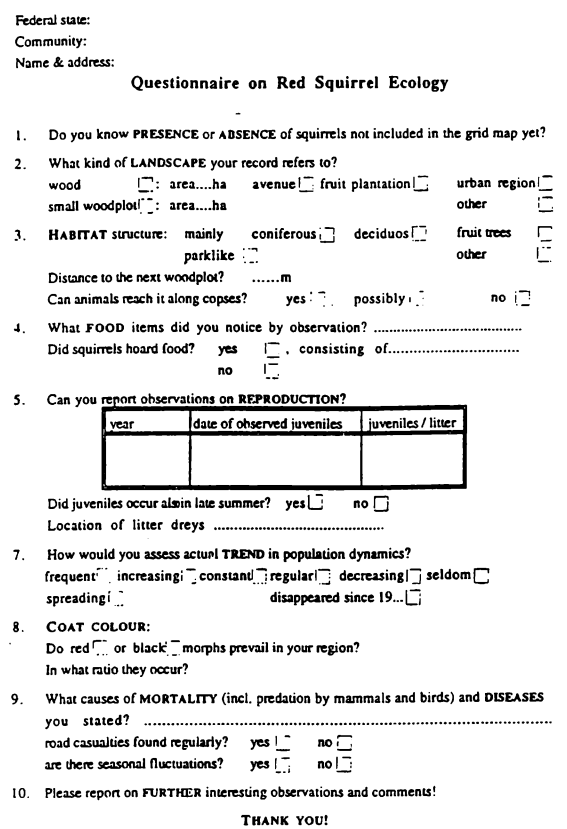
Squirrel questionnaires - silly answers to serious questions!

KRISTIN ZSCHEILE & LOUISE MAGRIS

Questionnaire surveys provide a useful tool for large-scale data sampling. However several limitations have to be taken into consideration during planning as well as analysing surveys. We present our experiences on effectivity and possible pitfalls from two surveys on a regional (Jersey, Channel Islands, U.K.) and a state-wide scale (Eastern Germany).



Federal state:
Community:
Name & address:

Questionnaire on Red Squirrel Ecology

1. Do you know **PRESENCE** or **ABSENCE** of squirrels not included in the grid map yet?
2. What kind of **LANDSCAPE** your record refers to?
   wood ☐: area....ha avenue ☐ fruit plantation ☐ urban region ☐
   small woodplot ☐: area....ha other ☐
3. **HABITAT** structure: mainly coniferous ☐ deciduos ☐ fruit trees ☐
   parklike ☐ other ☐
   Distance to the next woodplot? .....m
   Can animals reach it along copses? yes ☐ possibly ☐ no ☐
4. What **FOOD** items did you notice by observation? .....
   Did squirrels hoard food? yes ☐, consisting of.....
   no ☐
5. Can you report observations on **REPRODUCTION**?

year	date of observed juveniles	juveniles / litter

   Did juveniles occur alsoin late summer? yes ☐ no ☐
   Location of litter dreys .....
7. How would you assess actuel **TREND** in population dynamics?
   frequent ☐ increasing ☐ constant ☐ regular ☐ decreasing ☐ seldom ☐
   spreading ☐ disappeared since 19...☐
8. **COAT COLOUR**:
   Do red ☐ or black ☐ morphs prevail in your region?
   In what ratio they occur?
9. What causes of **MORTALITY** (incl. predation by mammals and birds) and **DISEASES** you stated? .....
   road casualties found regularly? yes ☐ no ☐
   are there seasonal fluctuations? yes ☐ no ☐
10. Please report on **FURTHER** interesting observations and comments!

THANK YOU!

Fig. 1: Translated version of the squirrel questionaire used in the german survey

As a part of a mammal survey in Eastern Germany, we developed a questionnaire to compile actual presence/absence data for Red squirrels based on the national ordnance map grid (translated version of the questionaire see). The one-page questionaire provided in most cases several options to tick off. We sent the survey form to colleagues and published it in a popular game journal. Categorized counting was used for data analysis because of the episodic character of most records.

Only 9 % of replies based on our publication, indicated the low efficiency of non-personal sampling. More than half of grid points were given by some dozen mammalogists and colleagues in museums. Records on suburban environment were overrepresented. Inconsistent replies indicate that sometimes (how often?) children's book knowledge is reported rather than a personal observation: eg. hazelnuts were the only given food item where habitat was classified as pure coniferous forest. Several respondants misinterpreted questions.

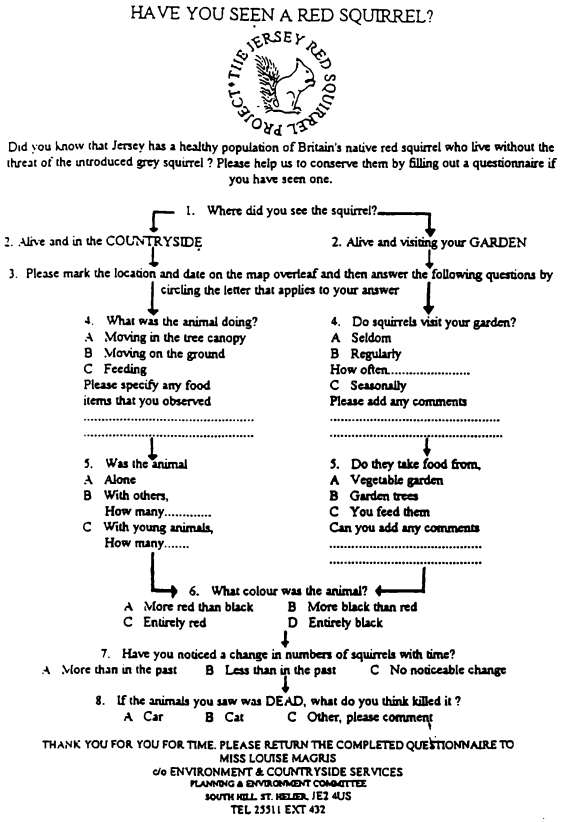


Fig. 2: Questionaire used in the Jersey squirrel survey

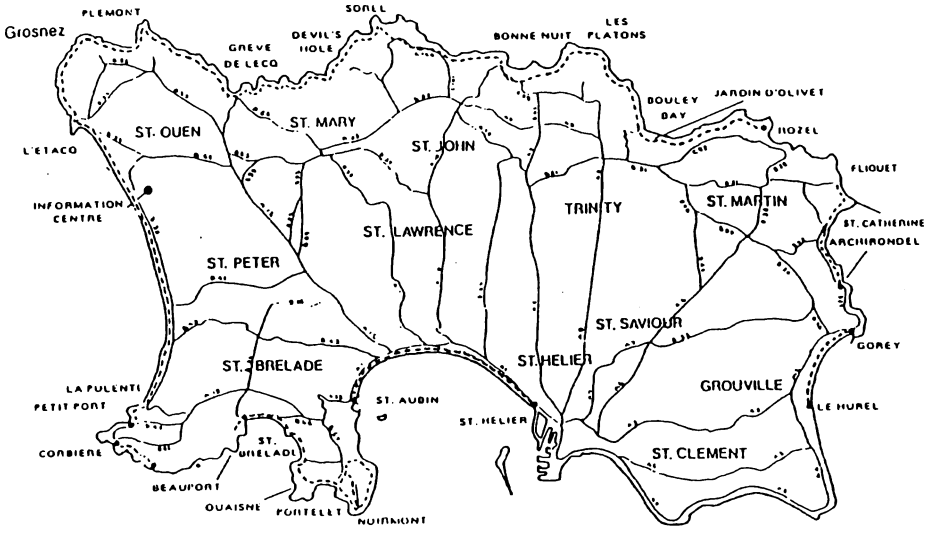


Fig. 3: Map used in the Jersey squirrel survey guestionaire

The Jersey questionnaire survey was intended to add to the known islandwide distribution of Red squirrels as well as to indicate the extent of garden feeding and causes of squirrel mortality. The questionnaire is of simple dichotomous design depending on whether the squirrel is seen in the countryside or in a garden. Survey forms have been distributed widely through public buildings and with a newsletter of a local environmental charity.

The return rate has been poor at 4,5 %. Cats and cars are the only causes of mortality confirming initial field results. The absence of Grey squirrels on the Island suggests reliability of observations. Nonetheless one sighting of a squirrel on an isolated, treeless coastal heath must surely be a polecat x ferret (*Mustela putorius* x *M.furo*)! 29 % of squirrels are observed feeding in gardens. Radio tracking data confirmed that 31 % of squirrels (n=22) regularly visit gardens suggesting that the survey is providing more reliable results than anticipated.

Comparing our experiences we recommend the following guide lines:
- The method is appropriate to obtain at least presence data on a large scale, but reliable absence data are not obtainable.
- Any questionnaire should be short (1 page limit) and requires concise questions.
- The respondant should be provided with potential answers. (By doing this, there is a possibility of influencing respondants answers which can be minimized by giving an option „other".)

- Before releasing the survey form a person naive to the topic should be asked to make a rigorous pitfall test.
- The way of launching and distributing questionnaires should be as personal as possible to improve reply rate.
- Check reliability of records by cross validation or by testing for obvious inconsistent replies. On a regional scale there is some chance to check for accuracy by random oral re-sampling or field tests, on a higher landscape level this is impossible. Forms with contradictions should be rejected from further analyses.
- Even pooling many single, episodic records does not necessarily result in representative data. Frequent and easy observable behaviour is probably overestimated.

- Plotting the distribution should be done on a scale relevant to the particular species. For smaller animals this is realizable at regional but not at state-wide level.

Keeping this in mind, questionnaire surveys provide a good starting point and basis for further investigations. On a regional scale they offer a chance for the public to become involved in a high profile study and help to raise species awareness.

Eichhörnchen Fragebögen - lustige Antworten zu ernsten Fragen!

Zusammenfassung

Fragebögen sind eine gute Möglichkeit Daten im großen Stil zu sammeln. Bei der Planung bzw. bei der Analyse von Fragebögen müssen jedoch einige beschränkende Aspekte berücksichtigt werden. Praktische Erfahrungen zur Nützlichkeit und zu den Problemen dieser Methode werden am Beispiel eines regionalen Projektes auf Jersey (Kanal Inseln, Großbritannien) sowie am Beispiel einer landesweiten Umfrage im östlichen Deutschland beschrieben.

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