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NATIVE AND ALIEN SQUIRRELS IN ITALY

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ABSTRACT - In Italy there are four species of squirrels: the native red squirrel and other three species recently introduced. The red squirrel is present in the Italian peninsula with three subspecies, and is missing only in Salento, and Italian islands. This species is common on Alps and Apennines, while in the plains it is declining because of the habitat loss. Competition with the grey squirrel and habitat fragmentation are considered the major threats to the survival of the red squirrel. The grey squirrel is present in Piedmont and Liguria. A study on the Piedmontese colony showed that the red squirrel is disappearing from the area colonised by the grey squirrel and the damage due to bark-stripping and feeding is considerable. Free-ranging populations of the Siberian chipmunk live in Belluno, Verona, and Rome, but records of single animals were reported for other areas. The Finlayson's squirrel is present with a small nucleus in an urban area of Piedmont. Here, the impact of this species on the vegetation appears dramatic. The eradication of the grey squirrel is a priority for the conservation of the red squirrel, but control plans for the other introduced species are also needed.

Key words: Red squirrel *(Sciurus vulgaris)*, Grey squirrel *(Sciurus carolinensis)*, Siberian chipmunk (*Tamias sibiricus)*, Finlayson's squirrel (*Callosciurus finlaysoni*), alien species, Italy.

INTRODUCTION

The introduction of alien species is one of the greatest threats to native biodiversity, only the destruction of habitat is worse. A UN report shows that 20% of the endangered vertebrate species are so because of introduced species (Baskin, 1996). Furthermore, a lot of aliens may interact negatively with human activities, thus causing a remarkable economic loss (Lever, 1994). The Convention on Biological Diversity, adopted in 1992 by the summit in Rio de Janeiro, and signed also by Italy, recognized these dangers and obliged all subscribing nations to prevent the introduction of new species and to control or eradicate those already introduced, which proved to cause a threat to the ecosystems.

The red squirrel *(Sciurus vulgaris)* is the only squirrel species naturally present in Italy, but other species have been introduced lately. These are: the grey squirrel *(Sciurus carolinensis)* that was introduced into Piedmont in 1948 and into Liguria in 1966; the Siberian chipmunk *(Tamias sibiricus)* released in different sites of North and Central Italy; the Finlayson's squirrel *(Callosciurus finlaysoni*) introduced into Acqui Terme **(AL)** 16-18 years ago. The presence of the grey squirrel in Italy poses a serious conservation problem: in fact this species competes with the native red squirrel and causes its disappearance. The first introduction into Europe of the grey squirrel occurred in Great Britain in the late 19th century (Laidler, 1980; Lloyd, 1983). In less than a century the alien squirrel has replaced the native one over most of the country (Reynolds, 1985; Usher *et al.*, 1992; Gurnell and Pepper, 1993); the same is happening in Italy (Wauters *et*

Table 1 - Presence of the red squirrel in different regions of Italy, differentiated in: widespread (+); localized (+/-); rare or absent (-). Data are taken from literature (Piemonte, Valle d'Aosta: S.TE.P., 1994; Lombardia: Prigioni *et al.*, in press; Venezia: Bon *et al.*, 1995; Friuli: Lapini *et al.*, 1996; Grosseto: Sforzi and Ragni, 1997; Forli: Gellini *et al.*, 1992; Marche: Pandolfi, 1992).

Area	Alps	Apennines	Hills	Plains
Valle d'Aosta	+			+/-
Piemonte	+	+	+	+/-
Lombardia	+	+	+/-	+/-
Venezia	+		+/-	
Friuli	+		+	
Grosseto		+	+	+
Forlì		+	+/-	
Marche		+	+	?

al., 1997b). Keeping in mind this situation there is a growing concern about the possible spread of the grey squirrel throughout the European continent.

The aim of this paper is: (i) to point out the status of the red squirrel and of the other introduced squirrels; (ii) to list the threats for the ecosystems where these species have been introduced; (iii) to supply information for the management of these species.

RED SQUIRREL
(Sciurus vulgaris Linnaeus, 1758)

The red squirrel has a Palaearctic distribution, from the Iberic peninsula to Japan. Up to date about 40 subspecies have been described, but most of them are dubious. In Italy three subspecies are present (Toschi, 1965), and the red squirrel is missing only in Salento (southern Apulia) and on the islands. On the Alps, and more generally north of the Apennines, one finds the subspecies *S. vulgaris fuscoater* Altum, 1876, which is also widespread in Central Europe. The pelage colour goes from light red to dark brown, almost black. In central Italy, north of Abruzzo, there is S. *v. italicus* Bonaparte, 1838, always having a light and a dark phase, but less intensively pigmented. Finally, in southern Italy, there is the subspecies S. v. *meridionalis* Lucifero, 1907, having the upper parts of the body black and the lower parts white. According to Cavazza (1913, in Cagnolaro, 1981) the body size increases gradually from the Alps to Calabria.

The red squirrel was hunted until 1977 and was considered a pest to forests in the past (Cagnolaro, 1981); nowadays this species is protected by the Italian law (no. 157/92). Until now an organic research on the status of the red squirrel in Italy is not available, but some information can be collected from mammal atlases published locally (Table 1). In northern Italy this species is common on Alps and pre-Alps, especially where there are mature and well grown forests, and it is present on most of the hills (S.TE.P., 1994; Bon ***et al.***, 1995; Lapini ***et al.***, 1996; Prigioni ***et al.***, in press). The situation in the plains is different; here this species is endangered and declining because of a high habitat fragmentation preventing the possibility of recolonisation when local extintion occurs. In Venetia and Friuli, the red squirrel is almost absent in the plains (Bon ***et al.***, 1995; Lapini ***et al.***, 1996), while in Piedmont and Lombardy it still occupies some large lowland woods, but local extinctions are common (Celada *et al.*, 1994). The information on central and

Table *2* – Tactics for conserving the red squirrel in Europe.

Management interventions useful to assure the survival of the red squirrel in Europe.
a) Eradication of the grey squirrel from Italy.
Management interventions useful to favour colonisation by the red squirrel in areas presently not occupied or dwelled in a non stable manner.
a) Modification of the present forms of forest management so to obtain an increase of the wilderness of woods.
b) In the plains, creation of ecological corridors to link isolated areas large enough (20-40 ha) to host a source population.
c) Application of re-iqtroduction or re-stocking programmes to favour the recolonization of suitable areas.

southern Italy is scanty. Gellini *et al.* (1992) consider this species common in almost all woods of the province of Forli (Romagna), Sforzi and Ragni (1997) point out a positive trend and the colonization of new areas in the province of Grosseto (Tuscany), while Pandolfi (1992) retains that the red squirrel is not present in all feasible environments of Marche. In any case, this species is absent from some areas of Latium where there are apparently good ecologic conditions (e.g. Cimini Mounts in the province of Viterbo; Lepini Mounts in the provinces of Rome, Latina and Frosinone; parts of the coast). The red squirrel can colonise urban areas, also of big cities, such as Rome (Cignini *et al.*, 1997), Bologna, Forli (Scaravelli and Di Girolamo, 1998), Gorizia, Trieste and Udine (Lapini *et al.*, 1996), when they host forest remnants.

The red squirrel is considered an endangered species in Europe (Amori and Zima, 1994; Mitchell-Jones *et al.*, 1999) and in Italy (Amori *et al.*, 1993). The competition with the grey squirrel and habitat fragmentation are considered the major threats to the survival of this species. At a regional scale, animal population dynamics are strongly affected by woodland isolation (Andrén, 1994). Research carried out in areas with a different degree of habitat fragmentation enabled to point out the factors which influenced the presence/absence of the red squirrel (Celada *et al.*, 1994; van Apeldoorn *et al.*, 1994, Verboom and van Apeldoorn, 1990; Asferg *et al.*, 1997). Wood size, presence of conifers, and nearby forests were positively correlated with the presence of the red squirrel. The distance from woods bigger than 20-30 ha (where a source population may be maintained) was negatively correlated with the presence of this species: an increasing distance decreased the chance to find a squirrel. In the only study made in Italy, Celada *et al.* (1994) pointed out the presence of the red squirrel only in 28.3% of the 46 wood areas investigated in the Po Plain, These were near the rivers Ticino and Po, where there are still woods of a certain size. Normally red squirrels do not disperse over open habitats, thus a landscape management must lead to the reduction of woodland isolation. The connection between woodland fragments containing a "source" population (20-40 ha in size), could be increased by planting hedgerows, treerows and small woodland patches (Wauters *et al.*, 1994; Wauters, 1997). Other management interventions useful to safeguard this species (Table 2) may be the increase of tree species quality and reintroduction programmes in areas considered suitable for the red squirrel (Fornasari *et al.*, 1997; Wauters *et al.*, 1997a). However, actions to favour the red squirrel will have a limited effect if the erad-

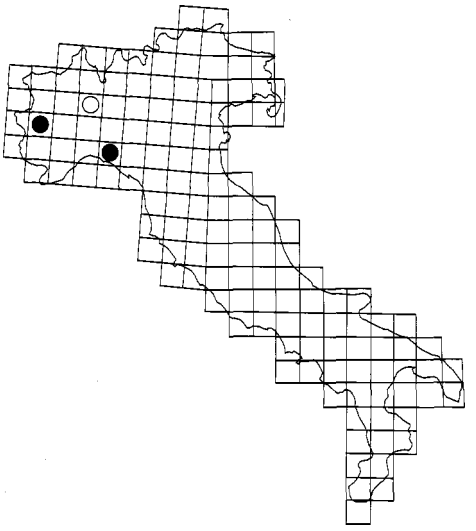

Figure 1 - Distribution of *Sciurus carolinensis* in Italy. UTM 50 km grid. Black circle: established population; empty cirle: colony partially removed.

ication of the grey squirrel will not take place soon (Table 2).

GREY SQUIRREL
(*Sciurus carolinensis* Gmelin, 1788)

This is a nearctic species, naturally present in the eastern part of North America. Its distribution has increased after the introductions into Great Britain (Middleton, 1930; Laidler, 1980; Lloyd, 1983; Gurnell, 1987), South Africa (Lever, 1985), and Italy (Currado *et al.*, 1987). The first introduction into Italy took place in Piedmont (northwestern Italy) (Fig. 1) in 1948, when two couples of grey squirrels coming from Washington D.C. were released at Candiolo (Turin) (Currado *et al.*, 1987). Presently this species occupies an area of about 450 km^2 in the provinces of Turin and Cuneo (Bertolino, unpublished data). Always in Piedmont, at Trecate (province of Novara), the townhall introduced in 1994 three couples of grey squirrels in the town park (Currado *et al.*, 1997). These animals came from an importer of Varese who had bought about *20* individuals from a Dutch importer, the rest of the animals had been sold to private customers of whom the importer said not to have kept any reference. **A** part of the squirrels of Trecate, which had reproduced in the meantime, have been captured by the local sanitary unit and given back to the importer (!). This species was still reported in 1997 at Trecate and it is probably present in the nearby Ticino Natural Park. The grey squirrel can be found in Liguria, where *5* individuals coming from Norfolk (Virginia) were introduced in 1966 into the park of Villa Groppallo at Genoa Nervi (Fig. 1) (Capocaccia Orsini and Doria, 1991). **A** survey in 1994 enabled to record the presence of this species also in the nearby towns of S. Ilario and Bogliasco (Oliva, 1995). Both in Piedmont and in Liguria, monitoring programmes are in progress with the technique of hair-tubes, so to determine precisely the actual territory occupied by this species (Bertolino *et al.*, 1998; Marsan, pers. comm.).

The grey squirrel has a strong negative impact on the natural habitats and on agricultural activities. In Great Britain its diffusion is causing the progressive disappearance of the red squirrel, which is presently exclusively restricted to pure conifer forests of Scotland and other few areas (Reynolds, 1985; Usher *et al.*, 1992; Gurnell and Pepper, 1993). Such a phenomenon is happening also in Italy (Wauters *et al.*, 1997b); so the competitive exclusion between both species would be confirmed. The impact of the grey squirrel is negative also for agro-forestal activities. In Great Britain this rodent causes heavy damage to forests and tree commercial plantations, because of bark-stripping on beech and hickory plants (Rowe and Gill, 1985; Kenward *et al.*, 1992). In Piedmont, damage to poplars, hornbeams and cereal crops have been recorded (Currado *et al.*, 1987; Currado, 1993).

The mechanisms which make the grey

squirrel replace the red one are not yet clear and several hypotheses have been suggested (Gurnell, 1987; Gurnell and Pepper, 1993; Kenward and Holm, 1993; Skelcher, 1997). The most probable explanation seems linked to the higher competitivity of the grey squirrel in the exploitment of environmental resources, especially in broadleaf and mixed woods. The grey squirrel weighs in average the double of the red squirrel (Gurnell, 1987, 1991a, 1991b) and it can increase its weight in autumn of about 20%, while the red squirrel has an increase of 10% (Kenward and Tonkin, 1986). Moreover, Kenward and Holm (1993) proved that the grey squirrel is thus able to exploit better the autumn stock of seeds with a high energy content produced by broadleaf trees, increasing its fat reserves, which are useful to pass winter. The red squirel, instead, is more vulnerable to food shortage periods. A greater weight in autumn does not help only to pass winter, but increases also the reproductive success (Wauters and Dhondt, 1989a, 1989b; Wauters ***et al.***, 1993; Gurnell 1996). Effectively, in the broadleaf woods the grey squirrel may reach a density of *2*-8 animals per ha, while the red squirrel does not generally go over 1 animal per ha; in conifer woods the density of both species is equal to about 1 animal per ha (Gurnell, 1987, 1991a, 1991b). In any case, the presence of some broadleaf trees (even < 1%) in the conifer woods permits the stable presence of the grey squirrel (Smith and Gurnell, 1997), favouring the replacement of the red squirrel in the long term. Recently, Wauters (1998) found out a lower survival rate in young red squirrels if grey squirrels are present, such a factor would be determinant in the replacement between these squirrels. The possible influence of diseases on population dynamics of red squirrels, already hypothesized in the past (Keymer, 1983), has had lately more confirmations. It seems in fact that a Parapox virus, identified in both species (Duff ***et al.***, 1996; Sainsbury *et al.*, 1997), may be maintained in grey squirrel populations and transmitted lethally to red squirrels. The risks connected to the presence of the grey squirrel in Italy are plenty. If the populations present in Piedmont and Liguria reach the Alps and the Apennines, an expansion of this species to the rest of Europe would be unavoidable, with a serious danger for the survival of the red squirrel and a dramatic economic impact on agriculture. In consideration of these problems, the Italian Wildlife Institute has started an experimental intervention project with the co-operation of the University of Turin. Such a project was blocked in 1997 by a report to the court made by an animal rights group.

SIBERIAN CHIPMUNK
(*Tamias sibiricus* Laxmann, 1769)

This is a small semi-terrestrial squirrel, with a natural distribution comprising the forest regions of northern Eurasia, eastern Finland and the countries on the White Sea; it arrives southwards to the Altai Mounts and northern China (Niethammer and Krapp, 1978). Naturalized colonies derived from escaped animals have become established in Austria, Belgium, France, Germany, Netherlands and Switzerland (Niethammer and Krapp, 1978; Lever, 1985; Fernandez, 1995). In Italy (Fig. **2),** free-ranging populations are found in Belluno, Verona, and Rome (Amori and Gippoliti, 1995; Dal Farra *et al.*, 1996). Other records of *T. sibiricus* were reported for Bolzano, Genoa, Padua, Trino Vercellese, and Udine (Currado *et al.*, 1987; Dal Farra *et al.*, 1996), but it is probable that some individuals have been released also in other sites. The colony of Belluno came from several animals which had escaped from a big importer and presently it has occupied an area of 5-6 km along the river Piave (Dal Farra *et al.*, 1996). The area where this species is present includes the river woods and the surrounding areas with meadows and cultivations alternated with woodlots and hedges (Dal Farra *et al.*,

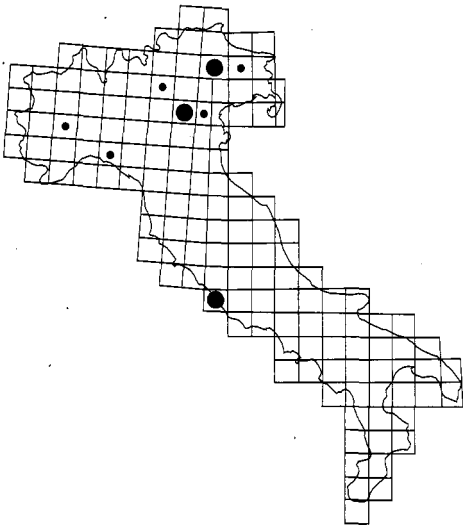

Figure 2 - Distribution of *Tamias sibiricus* in Italy. UTM 50 km grid. Black point: individuals; black circle: established population.

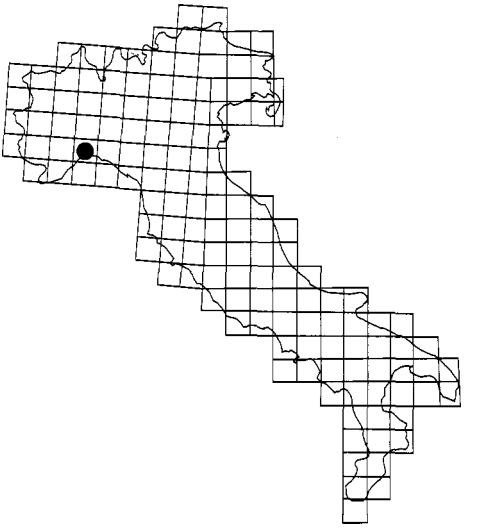

Figure 3 - Distribution of *Callosciurus finlaysoni* in Italy. UTM 50 **km** grid. Black circle: established population.

1996). No interaction of *Tamias sibiricus* with other species is known; both in Belluno and in Rome this species co-exists with *Sciurus vulgaris,* apparently without giving origin to interspecific competition (Amori and Gippoliti, 1995; Dal Farra *et al.,* 1996). However this species should be eradicated as a safety measure.

FINLAYSON'S SQUIRREL
(*Callosciurus finlaysoni* Horsfield, 1823)

This tree squirrel is present in Burma, Thailand, Laos, Cambogia and South Vietnam. Its pelage is extremely variable, therefore it is also called variable squirrel. The pelage may be black, red, white, or show parts with a different colour. Corbet and Hill (1992) identified sixteen subspecies. In the areas of origin, the Finlayson's squirrel has been recorded in different forest habitats, including dense forests, thin woods and coconut plantations (Lekagul and McNeely, 1988). Two couples of the Finlayson's squirrel were released in a 2 ha park at Acqui Terme (Alessandria) 16-18 years ago (Fig. 3). Presently there are about fifty animals which seem still concentrated in the original release area (Bertolino and Mazzoglio, unpublished data). The size and colour correspond to those of a population present in Thailand in the region of Thonburi north of Ayutthaya and belonging to the subspecies *C. finlaysoni bocourti* (Milne-Edwards, 1867), according to Corbet and Hill (1992). The impact of this species on the vegetation of the park of Acqui Terme appears considerable, a lot of old trees show vast barkstripping, sometimes so wide to compromise their survival (Bertolino *et al.,* in press). Such a phenomenon could be due to the high concentration of animals, or correspond to a typical behaviour of this species, maybe enhanced by the presence in a habitat different from the originary one. Lever (1985) reports on a similar behaviour shown by *Callosciurus caniceps,* which was introduced in the '40s in Japan. The same author reminds how,

in a few decades, from some animals escaped from a zoo, a population of about 20000 animals had taken origin. Bark-stripping is reported also for *Callosciurus erythraeus* (Kuo *et al.*, 1982; Zhu *et al.*, 1990). At present it is not possible to evaluate with certainty what will be the impact of *C. finlaysoni* once that it reaches the hills around Acqui Terme. Considering what happened in Japan with *C. caniceps* and the impact that *C. finlaysoni* may have on the vegetation, its diffusion must be absolutely avoided.

REEFERENCES

Amori, G., Angelici, F.M., Frugis, S., Gandolfi, G., Groppali, R., Lanza, B., Relini, G. and Vicini, G., 1993. Vertebrata. In: Minelli, A., Ruffo, S. and La Posta, S. (eds.), Checklist delle specie della fauna italiana, 110. Calderini, Bologna.

Amori, G. and Gippoliti, S., 1995. Siberian chipmunk *Tamias sibiricus* in Italy. Mammalia, 59(2): 288-289.

Amori, G. and Zima, J., 1994. Threatened Rodents in Europe: species status and some suggestions for conservation strategies. Folia Zoologica, 43(1): 1-9.

Andrén, H., 1994. Effect of habitat fragmentation on birds and mammals in landscape with different proportion of suitable habitat: a review. Oikos, 71: 355-366.

Asferg, T., Moller Nielsen, S., Rosengaard, M. and Bertelsenn, J., 1997. Presence/absence of red squirrel *Sciurus vulgaris* in Danish woodlots: demonstration of fragmentation effects. III European Squirrel Workshop, Bavaria, Germany. Saugetierkundliche Informationen, 21.

Baskin, Y., 1996. Curbing undesirable invaders. BioScience, 46(10): 732-736.

Bertolino, S., Currado, I., Mazzoglio, P.J. and Vaiana, M., (in press). Danni a impianti per l'arboricoltura da legno provocati da Sciuridae alloctoni introdotti in Italia. II Congresso Nazionale di Selvicoltura, Venezia, 24-27 giugno 1998.

Bertolino, S., Currado, I., Mazzoglio, P.J. and Pallavicino, L., 1998. L'uso degli hair-tubes nel monitoraggio di roditori arboricoli. II Congresso Italiano di Teriologia, Varese, Abstract book: 172.

Bon, M., Paolucci, F., De Battisti, R. and Vernier, E. (eds.), 1995. Atlante dei Mammiferi del Veneto. Lavori Soc. Ven. Sc. Nat., (n.s.) 21: 60.

Cagnolaro, L., 1981. Scoiattolo *Sciurus vulgaris* Linnaeus, 1758. In: AA.VV. Distribuzione e biologia di 22 specie di Mammiferi in Italia. Progetto finalizzato "Promozione della qualitb dell'ambiente", AQ/1/142-164, CNR Roma: 27-30.

Capocaccia Orsini, L. and Doria, G., 1991. L'utile, il dilettevole, il clandestino: la fauna europea si trasforma. In: Capocaccia Orsini, L., Doria, G. and Doria, G. (eds.). 1492-1992: Animali e piante dalle Americhe all'Europa. SAGEP Editrice, Genova: 33-63.

Celada, C., Bogliani, G., Gariboldi, A. and Maracci, A., 1994. Occupancy of isolated woodlots by the red squirrel *Sciurus vulgaris* L. in Italy. Biological Conservation, 69: 177-183.

Cignini, B., Cristaldi, M. and Sartoretti, A., 1997. Lo Scoiattolo *Sciurus vulgaris* L., 1758 nella cittb di Roma. Ecologia Urbana, 9(2-3): 14-15.

Corbet, G.B. and Hill, J.E., 1992. The mammals of the Indomalayan region: a systematic review. Natural History Museum publications, Oxford University Press.

Currado, I., 1993. Lo scoiattolo grigio americano *(Sciurus carolinensis* Gmelin), nuovo nemico per l'arboricoltura da legno in Italia (Rodentia: Sciuridae). Convegno Arboricoltura da legno e politiche comunitarie, Tempio Pausania: 85-94.

Currado, I., Scaramozzino, P.L. and Brussino, G., 1987. Note sulla presenza dello Scoiattolo grigio *(Sciurus carolinensis*

Gmelini, 1788) in Piemonte (Rodentia: Sciuridae). Ann. Fac. Sci. Agr. Univ. Torino, 14: 307-331.

Currado, I., Mazzoglio, P.J., Amori, G. and Wauters, L., 1997. Rischi biologici delle introduzioni: il caso dello Scoiattolo grigio *(Sciurus carolinensis* Gmelin, 1788) in Italia. In: Spagnesi, M., Toso, S. and Genovesi, P. (eds.). Atti del III Convegno Nazionale dei Biologi della Selvaggina. Suppl. Ric. Biol. Selvaggina, 27: 277-284.

Dal Farra, A., Cassol, M. and Lapini, L., 1996. Status del Burunduk *(Tamias sibiricus* [Laxmann, 17691, Rodentia, Sciuridae) nel Bellunese (Italia Nord-Orientale). Boll. Mus. civ. St. nat., Venezia, 45 (1994): 189-193.

Duff, J.P., Scott, A. and Keymer, I.F., 1996. Parapox virus infection of the grey squirrel. Mammal News, The Quaterly Newsletter of the Mammal Society: 10.

Fernandez, H., 1995. *Tamias sibiricus* (Laxmann, 1769). In: AA.VV. Mammiferi della Svizzera. Distribuzione, biologia, ecologia. Birkhauser Verlag, Basel-Boston-Berlin: 236-238.

Fornasari, L., Casale, P. and Wauters, L.A., 1997. Red squirrel conservation: the assessment of a reintroduction experiment. Ital. J. Zool., 64: 163-167.

Gellini, S., Casini, L. and Matteucci, C. (eds.), 1992. Atlante dei mammiferi della Provincia di Forli. Maggioli Editore, 179 pp.

Gurnell, J., 1987. The natural history of Squirrels. Christopher Helm, London, pp. 201.

Gurnell, J., 1991a. The red squirrel. In: Corbet, G.B. and Harris, S. (eds.). The Handbook of British Mammals. Blackwell Scientific Publications, Oxford: 176-186.

Gurnell, J., 1991b. The grey squirrel. In: Corbet, G.B. and Harris, S. (eds.). The Handbook of British Mammals. Blackwell Scientific Publications, Oxford: 186-191.

Gurnell, J., 1996. The effects of food availability and winter weather on the dynamics of a grey squirrel population in southern England. Journal of Applied Ecology, 33: 325-338.

Gurnell, J. and Pepper, H., 1993. A critical look at conserving the British red squirrel *Sciurus vulgaris.* Mamm. Rev., 23: 125-136.

Kenward, R.E. and Tonkin, J.M., 1986. Red and Grey squirrels: some behavioural and biometric differences. J. Zool. Lond., 209: 279-281.

Kenward, R.E. and Holm, J.L., 1993. On the replacement of the red squirrel in Britain: a phytotoxic explanation. Proceedings of the Royal Society of London B, 251: 187-197.

Kenward, R.E., Parish, T. and Robertson, P.A., 1992. Are tree species mixtures too good for grey squirrel? In: Cannel, M.G.R., Malcolm, D.C. and Robertson, P.A. (eds.). The ecology of mixed species stands of trees. Blackwell Scientific Publishers, Oxford: 243-253.

Keymer, I.F., 1983. Diseases of squirrels in Britain. Mammal Review, 13: 155-158.

Kuo, P.C., Kao, C., Liu, C.F. and Hwang, F.D., 1982. Correlation of the damage by Formosan red-bellied squirrel with chemical composition of wood: Part III. Sugar content of bark. Memoirs of the College of Agriculture National Taiwan University, 22(2): 25-36.

Laidler, K., 1980. Squirrels in Britain. David & Charles, North Pomfret, 192 pp.

Lapini, L., Dall'Asta, A., Dublo, L., Spoto, M. and Vernier, E., 1996. Materiali per una Teriofauna dell'Italia Nord-orientale (Mammalia, Friuli-Venezia Giulia). Gortania, Atti del Museo Tridentino di Storia Naturale, 17 (1995): 149-248.

Lekagul, B. and McNeely, J.A., 1988. Mammals of Thailand. Darnsutha Press, Bangkok, 759 pp.

Lever, C., 1985. Naturalized mammals of the world. Longman, London and New York, 497 pp.

Lever, C., 1994. Naturalized animals. T. and AD. Poyser Natural History, London, 354 pp.

Lloyd, H.G., 1983. Past and present distribution of red and grey squirrels. Mammal Review, 13: 155-158.

Middleton, A.D., 1930. The ecology of the American grey squirrel in the British Isles. Proceedings of the Zoological Society of London, 809-843.

Mitchell-Jones, A.J., Amori, G., Bogdanowicz, W., Kryštufek, B., Reijnders, P.J.H., Spitzenberger, F., Stubbe, M., Thissen, J.B.M., Vohralik, V. and Zima, J., 1999. The Atlas of European Mammals. The Academic Press, London. 496 pp.

Niethammer, J. and Krapp, F., 1978. Handbuch der Saugetiere Europas. Band 2/I: Rodentia II. Akademische Verlagsgesellschaft, Wiesbaden: 116-121.

Oliva, E., 1995. Lo Scoiattolo grigio *(Sciurus carolinensis* Gmelini, 1788) in Liguria: problematiche di una reintroduzione. Graduation Thesis, University of Genoa, 84 pp.

Pandolfi, M., 1992. Fauna nelle Marche. Mammiferi e Uccelli. Regione Marche, Il Lavoro editoriale, 133 pp.

Prigioni, C., Cantini, M. and Zilio, A., (in press). Atlante dei Mammiferi della Lombardia. Regione Lombardia.

Reynolds, J.C., 1985. Details of the geographic replacement of the red squirrel *(Sciurus vulgaris)* by the grey squirrel *(Sciurus carolinensis)* in eastern England. J. Anim. Ecology, 54: 149-162.

Rowe, J.J. and Gill, M.A., 1985. The susceptibility of tree species to bark-stripping damage by grey squirrels *(Sciurus carolinensis)* in England and Wales. Quaterly Journal of Forestry, 79: 183-190.

Sainsbury, A.W., Nettleton, P. and Gurnell, J., 1997. Recent developments in the study of parapoxvirus in red and grey squirrels. In: Gurnell, J. and Lurz, P. (eds.). The Conservation of Red Squirrels, *Sciurus vulgaris* L. People Trust for Endangered Species: 105-108.

Scaravelli, D. and Di Girolamo, A., 1998. La colonizzazione delle città romagnole da parte di *Sciurus vulgaris* L., 1758. In: Bologna, M.A., Carpaneto, G.M. and Cignini, B. (eds.). I" Convegno sulla Fauna Urbana, Fratelli Palombi Editori: 233-234.

Skelcher, G., 1997. The ecological replacement of red by grey squirrels. In: Gurnell, J. and Lurz, P. (eds.). The Conservation of Red Squirrels, *Sciurus vulgaris* L. People Trust for Endangered Species: 67-78.

Sforzi, A. and Ragni, B., 1997. Atlante dei Mammiferi della provincia di Grosseto. Atti Museo di Storia Naturale della Maremma, n. 16 (suppl.).

Smith, D. and Gurnell, J., 1997. The ecology of the grey squirrel, *Sciurus carolinensis,* in conifer forest. In: Gurnell, J. and Lurz, P. (eds.). The Conservation of Red Squirrels, *Sciurus vulgaris* L. People Trust for Endangered Species: 109-119.

S.TE.P. (Stazione Teriologica Piemontese), 1994. Progetto Atlante Mammiferi Piemonte - Valle D'Aosta. Dati al 31/05/93. Unpublished report.

Toschi, A., 1965. Fauna d'Italia VII. Mammalia: Lagomorpha, Rodentia, Carnivora, Ungulata, Cetacea. Calderini, Bologna, 647 pp.

Usher, M.B., Crawford, T.J. and Banwell, J.L., 1992. An American Invasion of Britain: The Case of the Native and Alien *(Sciurus)* species. Conservation Biology, 6: 108-115.

Van Apeldoorn, R.C., Celada, C. and Nieuwenhuizen, W., 1994. Distribution and dynamics of the red squirrel *(Sciurus vulgaris* L.) in a landscape with fragmented habitat. Landscape Ecology, 9: 227-235.

Verboom, B. and van Apeldoorn, R.C., 1990. Effects of habitat fragmentation on the red squirrel, *Sciurus vulgaris* L. Landscape Ecology, 4: 171-176.

Wauters, L., 1997. The ecology of red squirrels *(Sciurus vulgaris)* in fragmented

habitats: a review. In: Gurnell, J. and Lurz, P. (eds.). The Conservation of Red Squirrels, *Sciurus vulgaris* L. People Trust for Endangered Species: 5-12.

Wauters, L., 1998. La competizione interspecifica tra scoiattolo grigio e scoiattolo rosso in Italia. II Congresso Italiano di Teriologia, Varese, Abstract book: **8.**

Wauters, L.A. and Dhondt, A.A., 1989a. Variation in length and body-weight of the red squirrel *(Sciurus **vulgaris**)* in two different habitats. Journal of Zoology, 217: 93-106.

Wauters, L.A. and Dhondt, A.A., 1989b. Body weight, longevity and reproductive success in red squirrel *(Sciurus vulgaris)*. J. Anim. Ecol., 58: 637-651.

Wauters, L.A., Bijens, L. and Dhondt, A.A., 1993. Body mass at weaning and juvenile recruitment in the red squirrel. J. Anim. Ecol., 62: 280-286.

Wauters, L.A., Casale, P. and Dhondt, A.A., 1994. Space use and dispersal of red squirrels in fragmented habitats. Oikos, 69: 140-146.

Wauters, L.A., Casale, P. and Fornasari, L., 1997a. Post-release behaviour, home range establishment and settlement success of reintroduced red squirrels. Ital. J. Zool., 64: 169-175.

Wauters, L.A., Currado, I., Mazzoglio, P.J. and Gurnell, J., 1997b. Replacement of red squirrels by introduced grey squirrels in Italy. In: Gurnell, J. and Lurz, P. (eds.). The Conservation of Red Squirrels, *Sciurus vulgaris* L. People Trust for Endangered Species: 79-88.

Zhu, **Y.,** Zhang, W. and Zhu, X., 1990. Bark-stripping damage to forest trees by red-bellied tree squirrel *(Callosciurus erythraeus)* in Zhejiang Province. Acta Theriologica Sinica, 10(4): 276-281.