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Movement and mortality of translocated urban–suburban grey squirrels

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Abstract

*During summer and autumn of 1994–1997, we determined the movements and mortality of 38 adult male Eastern grey squirrels (*Sciurus carolinensis*) that had been captured in urban–suburban backyards and translocated to a large forest. The squirrels did not fare well. Squirrels not found dead or classified as 'probable mortality' disappeared from the forest with a median time to disappearance of 11 days. Ninety-seven per cent (37 of 38) of the squirrels either died or disappeared from the release area within 88 days.*

Keywords: *animal welfare,* Sciurus carolinensis*, squirrel, translocation, urban, wildlife*

Introduction

Urban and suburban residents often consider grey squirrels (*Sciurus carolinensis*) troublesome because of the damage they inflict on gardens and their habit of nesting in attics and eating food intended for birds. In fact, raccoons and squirrels are among the most common nuisance mammals in North America (de Almeida 1987). A biologist in Maryland who helps residents to solve pest problems reported that 90% of his calls deal with grey squirrels, birds, snakes and bats (W Bridgeland, personal communication 1992). Live capture–translocation has traditionally been viewed by the public as a humane method of dealing with these 'problem' squirrels. Captured squirrels are typically driven a few kilometres away and released into a park or some other wooded area on the assumption that the animals will quickly settle into the new environment. The objective of the present study was to determine movement patterns and mortality of urban–suburban 'problem' squirrels that were translocated to a large forest.

Methods

Thirty-nine adult male Eastern grey squirrels (mean weight 532 g) were live-trapped in urban–suburban backyards within the Baltimore–Washington Metropolitan Area during the summers of 1994–1997 (Table 1). The squirrels either were causing damage to residential properties or were otherwise considered 'nuisance' animals by homeowners. Soon after capture, each squirrel was released from the trap into a mesh bag and anaesthetised with the inhalant methoxyflurane (Barry 1972). A quart jar containing a folded paper towel wetted with methoxyflurane was used to administer the anaesthetic. The animal was quickly subdued and its head placed in the jar opening. Dosage was monitored by closely observing the breathing rate and degree of muscle relaxation. When breathing slowed and muscle tonus was absent in the limbs, the anaesthetic was withdrawn. If the squirrel revived slightly during handling, additional anaesthetic was administered. Each squirrel was then examined, weighed, and fitted with an 18–19 g radio-collar (Advanced Telemetry Systems: Isanti, Minnesota, USA) with a 120 day battery life and a 4 h mortality switch. The motion-sensitive mortality switch doubled the pulse rate of the transmitter from 55 pulses per minute to 110 pulses per minute after 4 h if the collar remained motionless for that time period. Squirrels were held overnight in the traps in a darkened environment with food and water to ensure that the transmitter was functioning and not causing discomfort to the squirrel.

After the overnight observation period, squirrels were taken to the US Department of the Interior's Patuxent Wildlife Research Center near Laurel, Maryland, and released in the interior of the Center's 2389 ha oak–pine refuge. Five dispersed release sites were selected and no more than two squirrels were released at a site on any given day. In an effort to not 'stockpile' squirrels, a release site was not reused until fewer than two radio-tagged squirrels were detected within a 200–300 m radius of the site. For release, traps were placed on the forest floor and opened. Squirrels immediately left the traps and moved to the treetops.

All animals were monitored on the day of release and once or twice weekly thereafter. Squirrels were followed using a TR2 receiver (Telonics: Mesa, Arizona, USA) and a two-element 'H antenna'. Home range size (more appropriately considered 'area of use' in the present study) was calculated as a minimum convex polygon with TELEM88 (Coleman & Jones 1988). Fieldwork was conducted during the summer

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Table 1 Record of nuisance urban–suburban Eastern grey squirrels translocated to the Patuxent Research Refuge near Laurel, Maryland, 1994–1997.

Squirrel #	Release date	Release site	Fate[a]	Comments
1	25 Jun '94	1	D	Last located on 8 Sep '94.
2	28 Jun '94	1	D	Last located on 26 Aug '94.
3	12 Jul '94	1	M	By next day had moved about 2 km from release site. Found dead near release site 2 on 17 Jul '94. Carcass located in fairly open mixed pine–hardwood, at base of a beech tree. Decomposed, hard to see. Being fed on by beetles. Cause of death unknown.
4	15 Jul '94	1	D	Last located on 2 Sep '94.
5	21 Jul '94	1	PM	By next day had moved about 1.6 km. Continued to move extensively through 27 Jul '94. Found collar on 10 Aug '94.
6	28 Jul '94	2	PM	Found collar on 30 Jul '94.
7	5 Aug '94	2	D	Last located on 11 Aug '94.
8	22 Aug '94	2	PM	Retrieved collar on 7 Sep '94.
9	22 Aug '94	2	PM	Retrieved collar on 29 Aug '94.
10	24 Aug '94	2	PM	Retrieved collar on 7 Sep '94.
11	26 Aug '94	1	D	Could not locate on 29 Aug '94.
12	15 Sep '94	1	M	Killed by hunter on 8 Nov '94.
13	22 Sep '94	1	PM	Mortality signal from top of tree on 26 Sep '94.
14	5 Jun '95	1	D	Could not locate on 20 Jun. Located in backyard in Bowie, MD, on 23 Jul '95 (over 6.4 air kilometres away). Not located after 7 Aug '95.
15	11 Jul '95	1	D	Last located on 13 Jul '95.
16	11 Jul '95	1	D	Last located on 1 Aug '95.
17	12 Jul '95	1	D	Last located on 13 Jul '95.
18	13 Jul '95	1	PM	Last located on 1 Aug '95. Retrieved collar on 4 Aug '95. Tooth or claw marks on collar?
19	13 Jul '95	1	D	Could not locate 15–26 Jul '95. Last located on 15 Aug '95.
20	11 Aug '95	1		Still being tracked as of 10 Nov '95.
21	18 Jun '96	3	M	Remained near release site for 1 day then moved considerable distance. Carcass found on 25 Jun '96 (alive on 22 Jun '96) at base of a large tulip poplar tree (containing cavities). Hole in top of head. Cause of death unknown.
22	19 Jun '96	3	D	Last located on 21 Jun '96.
23	21 Jun '96	3	M	Did not move far. Retrieved collar on 5 Jul '96 at base of snag. Part of tail remaining. Tooth marks on collar? Maybe fox?
24	21 Jun '96	4	M	Did not move far. Retrieved collar at fox den on 28 Jun '96.
25	22 Jun '96	3	M	Moved far. Mortality signal on 21 Jul '96 (last known alive on 28 Jun '96). Retrieved collar on 27 Jul '96. Skull near collar.
26	22 Jun '96	3	M	Did not move far. Mortality signal on 21 Jul '96. Retrieved collar from leaf nest about 6.1 m from ground in an oak tree. Decomposed carcass. Tooth marks on transmitter.
27	28 Jun '96	5	PM	Retrieved collar on 2 Aug '96.
28	5 Jul '96	5	D	Could not locate on 4 Oct '96. Last heard on 27 Sep '96.
29	24 Jul '96	3	PM	Retrieved collar on 2 Aug '96. Last known alive on 26 Jul '96.
30	4 Aug '96	3	D	Never located again.
31	1 Jun '97	3	D	Last located on 4 Jun '97.
32	1 Jun '97	3	D	Last located on 5 Jun '97.
33	5 Jun '97	3	M	Located on 20 Jun '97. Moved about 1.6 km. Retrieved collar on 23 Jun '97. Part of tail remaining. Fox scat in area.
34	5 Jun '97	4	M	Not located until mortality signal detected on 28 Jul '97. Retrieved collar on 4 Aug '97 inside standing snag about 6.4 air kilometres from release site. Decomposed carcass.
35	2 Jul '97	3	D	Last located on 25 Sep '97.
36	2 Jul '97	3		Retrieved collar on 4 Jul '97. Attachment failure.
37	7 Jul '97	3	PM	Mortality signal on 11 Aug '97. Retrieved collar on ground about 1.6–2.4 air kilometres from release site. Not located up to that point.
38	7 Jul '97	3	D	Never located after release.
39	6 Aug '97	3	D	Last located on 29 Aug '97.

[a] D = disappeared; M = mortality; PM = probable mortality.

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and autumn seasons of 1994–97, and the research protocol was approved by the Animal Care and Use Committee of Patuxent Wildlife Research Center.

Results

Mortality

Five carcasses (#3, 12, 21, 26, 34) and partial remains of four other squirrels (#23, 24, 25, 33) were found; six carcasses or remains were located considerable distances from the release sites (1.6–6.4 km) and three were recovered near the release sites (Table 1). There was some evidence that four of these squirrels (excluding one shot by a hunter) were taken by predators, probably foxes (*Urocyon cinereoargenteus* or *Vulpes vulpes*). Two of the retrieved collars had what appeared to be tooth marks on them. One of these (#23) had part of the tail remaining and the other (#26) may have escaped to a leaf nest and died. Of the other two collars, one was retrieved at a fox den (#24) and the other had part of the tail remaining with fox scat in the area (#33).

We are reluctant to speculate on the cause of death of the remaining four squirrels (Table 1). Two of these (#3, 34) were highly decomposed. Only a skull remained on the ground near the collar of one (#25). One (#21) was returned to the lab for more detailed examination by one of the authors (VF) but cause of death could not be determined.

We classified 10 squirrels as 'probable mortality' (Table 1). Nine collars from these squirrels were retrieved from the forest floor (#5, 6, 8–10, 18, 27, 29, 37) and eight were located near release sites. Collars from four of the five squirrels released at site 2 (#6–10) were found on the forest floor nearby and the fifth animal disappeared after seven days. Searching the area revealed that the site was centred within a red-tailed hawk (*Buteo jamaicensis*) territory. Thereafter, no more animals were released at site 2 and that kind of concentrated loss of squirrels was not encountered at other release sites.

Movement

In the present study, areas of use were calculated for 16 squirrels remaining on-site for at least 15 days. The median size of these areas was 1.6 ha (range < 1 to 85 ha). Typically, squirrels did not move far on the day of release. However, all squirrels but one (of 18) that were not found dead or classified as 'probable mortality' disappeared from the large forest with a median time to disappearance of 11 days (Table 2). Nine animals disappeared within one week of release. One squirrel, released on 5 June 1995, moved about 1.6 km and settled into an area for about 15 days. On 20 June it disappeared only to reappear on 23 July eating birdseed in the backyard of a home in Bowie, Maryland (some 6.4 km from the release site). The squirrel remained there, in the presence of other squirrels, until 7 August when it disappeared. Four other animals released between 25 June and 15 July (in 1994, 1996, and 1997) settled into areas for extended time periods (54–88 days) but all disappeared during September of the year of release.

Table 2 Fate of translocated urban–suburban Eastern grey squirrels in Central Maryland, USA, 1994–1997.

Fate[a]	Number of squirrels	Days until death/disappearance Median	Range
Died[b]	8	14	5–54
Probably died[c]	9	15	2–32
Disappeared	18	11	1–88

[a] Tracking was terminated after 91 days for one squirrel (#20), and one squirrel (#36) lost its collar because of a faulty fastener.
[b] Time to death of one additional squirrel (#34) could not be determined.
[c] Time to loss (probable mortality) of one additional squirrel (#37) could not be determined.

Four squirrels (of the 18 that eventually disappeared) settled into areas for 21 to 42 days before they disappeared. One of these animals moved extensively and for some days it could not be located. It finally vanished after 42 days. The second squirrel moved over 2.4 km from the release site and disappeared after 23 days. The third squirrel stayed near the release site for two days, then disappeared; it reappeared 11 days later near the release site. There it stayed for 20 days longer before all contact was lost. The fourth squirrel remained close to the release site for 21 days before it vanished.

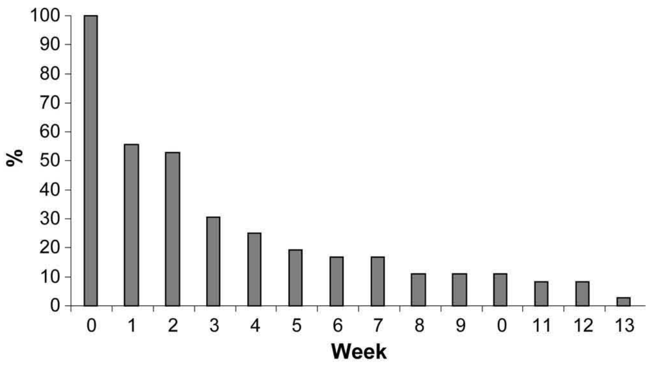
Discussion

Squirrels translocated to Patuxent Research Refuge did not fare well. Ninety-seven per cent (37 of 38) either died or disappeared from the refuge within 88 days of release (Figure 1). Excluding animals that disappeared and those classified as probable deaths, mortality after one month was 41% (7 of 17 animals). This is a high loss rate. Typically, annual mortality is about 50% in wild populations of the species (Flyger 1956; Mosby 1969; Barkalow *et al* 1970; Thompson 1978a). This rate also applies to the red squirrel (*Sciurus vulgaris*) (Gurnell 1987). One might suspect that mortality would also be high for animals that disappeared and that squirrels translocated during the winter months would sustain higher mortality than reported here (reviewed in Koprowski 1994).

High mortality of translocated nuisance animals has also been reported for white-tailed deer (*Odocoileus virginianus*; Bryant & Ishmael 1991) and raccoons (*Procyon lotor*; Frampton & Webb 1973; Wright 1977; Rosatte & MacInnes 1989). However, Mosillo *et al* (1999) found no difference in survival of resident raccoons of a rural Illinois forest preserve and suburban and rural raccoons translocated to the preserve. These investigators speculated that mild autumn weather conditions and abundant food and cover provided by agricultural crops may have been influential in their study.

In addition to serving as a technique for moving nuisance animals, translocation is also used to re-establish extirpated populations and to return orphaned or rehabilitated animals to the wild. The limited research conducted to date indicates that mortality may be high under these circumstances also. For example, Wauters *et al* (1997) released 19 red squirrels to a large urban park (108 ha) in Antwerp, Belgium, where

Figure 1



Percentage of translocated squirrels remaining in the Patuxent Research Refuge near Laurel, Maryland, USA, following release in 1994–1997.

the species was extirpated in the 1960s. One month after release, the mortality rate for males was 45% (similar to the 41% found in the present study) and for females 30%. Some animals suffered 'manipulation stress'. They exhibited little or no activity, did not feed, and died after a few days. Others showed normal exploratory and feeding activity but appeared vulnerable to predation by domestic dogs and cats. Predation and vehicles were major causes of the high mortality rate observed.

Reeve (1998) released 10 female hedgehogs (*Erinaceus europaeus*), captured as uninjured juvenile orphans in autumn 1994, into a rural woodland of low natural hedgehog density in England in June 1995. He observed a high level of dispersal and a low survival rate, perhaps resulting in part from the animals' low level of previous experience in the wild. His data support a general pattern for hedgehog releases reported by others and he stated that low overall survival of hedgehogs released from captivity is a serious cause for concern. A review of translocation and release of animals in Europe was published by Sainsbury *et al* (1995). These authors pointed out that few data exist on post-release survival but in some reported cases it is quite low. Craven *et al* (1998) provided a recent review of issues surrounding the translocation of problem wildlife.

We do not believe that the mortality of radio-tagged squirrels in our study was caused by the transmitter collars. Transmitters were similar to those used by Hougart (1974), who trapped and radio-collared eight squirrels (five male and three female) in a section of Northwest Branch Park, not far from our study site at the Patuxent Research Refuge. Hougart (1974) released his animals back into their home ranges and tracked each animal for a one-year time period without observing any mortality.

With one exception (an animal shot by a hunter), we cannot say with certainty what caused squirrel deaths. Based on general field observations, food appeared to be abundant, particularly acorns, and we observed translocated animals feeding at their new locations. We suspect that some squirrels were preyed upon by avian and mammalian predators. One collar was retrieved from the entrance to an active fox den seven days after release and what appeared to be tooth or claw marks were noted on a number of the retrieved collars.

The behaviour of resident squirrels trapped and released within their home range differs from the behaviour of squirrels trapped and relocated to a new area. Squirrels that are trapped and released in the same spot immediately scurry to the nearest den site and disappear within. Squirrels released into a new environment do not know the location of den sites, which may already be occupied, and the animals run rapidly over the ground for varying distances before scurrying up a tree where they may remain for the rest of the day. Others may travel from tree to tree through the canopy and remain exposed even when darkness falls.

The median area use value in the present study compares closely with reported home range sizes from other studies (varying from 0.5 ha to > 20.2 ha, but usually < 5 ha; Koprowski 1994). However, the variation of range sizes in the present study was broader than that reported by Koprowski (1994), reflecting the extensive movement of many translocated squirrels in the present study. The disappearance in September of the year of release of four squirrels that seemed to have settled into new home ranges is interesting. Autumn is typically the normal time of dispersal and reorganisation in squirrel populations (Flyger 1960; Gurnell 1987) and the squirrels' disappearance may have been related to this natural process. These data contrast sharply with those of Hougart (1974), who found that none of the eight resident squirrels he studied moved from their home ranges over a one-year time period. Roecker (1950) demonstrated that few, if any, squirrels return to the place of capture when released more than 8 km away.

Although grey squirrels (except for pregnant or nursing females) do not exhibit territoriality (Flyger 1955; Thompson 1978b; Don 1983), resident animals are aggressive toward newcomers (Bakken 1959; Taylor 1969; Thompson 1978a,b; Koprowski 1993). Such behaviour probably contributed to the higher mortality and movement rates of translocated squirrels in the current study.

In a 1700 ha red squirrel reserve in Thetford Forest, East Anglia, UK, translocation was used as a conservation tactic to reinforce red squirrel populations (Venning *et al* 1997). A 'soft release' was used whereby 17 squirrels were maintained in a 1 ha pre-release pen in the centre of the reserve for five weeks before release into the forest. On 1 September 1996, the squirrels were allowed to leave the pen and all did so some time during the first week, although some animals still used nests in the pen. During the first two weeks, six animals stayed within 1 km of the pen, three moved about 2.5 km away, one was found dead near a road 5 km from the pen, and one was observed 12 km away. Unfortunately, radio-transmitter problems developed and by 1 October 1996 contact was lost with all squirrels. One radio-collared squirrel was captured in February 1997 about 400 m from the pen. Generally, movement was similar to that observed by Wauters *et al* (1997) in Belgium. Wauters *et al* (1997) observed three types of post-release behaviour: some squirrels gradually explored the area around the release site and settled nearby; some females moved immediately and settled away from the release site; and some animals made several long-distance excursions (up to 1 km) interrupted by short-distance movements and then settled either near the release site or farther away.

Animal welfare implications

In the United States, and perhaps elsewhere, there is prevailing public belief that live capture and relocation is a humane solution to the problem of nuisance animals in and around the home and garden. The practice is widespread, although for some species (eg raccoons in Maryland, USA) this technique is illegal because of the potential for spreading rabies. The present study and other research show that relocated animals released in areas already containing the species move extensively in an effort to find a new home not already occupied by other individuals, and mortality of such relocated animals is high. In addition, removal of animals simply creates a vacuum at the problem site that is quickly filled by new animals. These facts are not well known by the general public. We believe that, where possible, one-way doors should be used to exclude animals from attics, basements, burrows under decks and porches, and similar situations. Animal access points should then be sealed to prevent re-entry. Compared to live capture and relocation, this approach would be preferable for solving many (but not all) problems. The offending animal would thus be removed from unwanted areas and be denied re-entry, but would remain in its home range. With this practice, no vacuum would be created for immigration of new animals. Increased effort should be made to educate the public regarding use of one-way doors.

Release of alien squirrels into new habitats may disturb resident squirrels, which are probably at the carrying capacity of the habitat. Diseases may be spread, social structure of resident squirrels may be disrupted, and competition for food and shelter may increase. Introductions might even cause a reduction of squirrels in the area. For example, translocation experiments with brown rats (*Rattus norvegicus*) in Baltimore, Maryland, by Davis (1949) demonstrated that rat numbers declined in those city blocks where newcomers were released.

We hope that practitioners and the public at large will become aware of the research reported here and begin to think twice before simply capturing unwanted animals and moving them to a nearby park or similar area. In addition, we recommend that further research be conducted on live capture and translocation. Perhaps translocation of females or of younger squirrels, or during other seasons, would be more successful. Further experimentation with methods of retaining squirrels at release sites before turning them loose may be worthwhile. We concur with Sainsbury *et al* (1995), who called for better education, better codes of practice, and more research into release techniques.

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