Fate of captive-reared brown hares Lepus europaeus released at a mountain site in central Italy

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SHORT COMMUNICATION

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Fate of captive-reared brown hares *Lepus europaeus* released at a mountain site in central Italy

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We conducted a radio-telemetry study of translocated brown hares *Lepus europaeus* during March 1992 - November 1994 in a mid-elevation mountain site in central Italy. Of 44 hares released in the study area, 38 died during our field studies. Most hares (68.2%) died within 10 days after release, 7.89% died within 11-20 days, 2.63% within 21-30 days and 21.05% later than 30 days after release. We found no difference in mortality rates between sexes. Most of the hares were preyed upon by red foxes *Vulpes vulpes* or beech marten *Martes foina*, but a few died of coccidiosis and various natural diseases. Some hares disappeared during the monitoring period. The average survival time was 52.7 days for males (N = 20), and 66.8 days for females (N = 21). We found no significant effect of sex, season or weight (g) on individual survival. Nearly all of the hares dispersed randomly from the release site within a radius of 1,200 m. We found no significant effect of survival time on dispersal rates, nor did we find any significant intersexual difference in the maximum distances moved by translocated individuals. We did not observe this trend among females. Season, survival time and individual weight did not influence individual dispersal, whereas sex had a significant effect, as males tended to disperse farther than females.

Key words: central Italy, dispersal, Lepus europaeus, mortality, radio-tracking, restocking hares, survival

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The brown hare *Lepus europaeus* is one of the most important game species in Europe, and has even been imported into Europe from other continents for hunting (*cf*. Spagnesi & Trocchi 1992). A crucial problem arises when natural populations of brown hares in Europe decline, because large numbers of captive hares originating from other regions are introduced to the wild. In general, translocations are unsuccessful because introduced hares fail to establish viable populations (e.g. Fiechter 1983, 1988, Pépin & Cargnelutti 1985, 1987, Marboutin, Benmergui, Pradel & Fiechter 1990, Angelici 1995, Riga, Boitani, Caporioni, Fioramonti, Gemma, Laurenti & Angelici 1997). However, the survival rates of the introduced hares vary considerably in relation to their origin. For example, translocated hares bred in captivity have a very low survival rate while wild-trapped hares have higher survival rates (e.g. Fiechter 1983, 1988, Pépin & Cargnelutti 1985, 1987, Benmergui, Reitz & Fiechter 1990, Marboutin et al. 1990).

All of the studies examining survival rates of translocated hares were done in intensively cultivated areas, without using radio-telemetry to monitor hare fate, and when telemetry was used, it was generally for very short time spans only (but see Marboutin et al. 1990 for an exception).

In this paper, we report the results of a radio-telemetry study of translocated hares, which was performed in the central Apennine mountains. The environmental characteristics of our study area were different from those of the study areas used in previously published studies of translocated hares. Studies within different habitats are crucial for our understanding of which general determinant may ensure ecologically successful translocations (Zörner 1981, Angelici 1995).

Material and methods

Study area

Our radio-telemetry study was conducted during March 1992 - November 1994 in a protected mountain site of 1,200 ha in central Italy (Capranica Prenestina, province of Rome, elevation 800-1,100 m a.s.l.). The area consists of mountain grasslands, pastures, extensive underbrush of *Rubus* spp., mixed broadleaf woodlands, including *Acer campestre, A. pseudoplatanus, Quercus pubescens, Q. cerris, Castanea sativa, Ostrya carpinifolia, Fagus sylvatica, Corylus avellana, Pyrus piraster*, conifer plantations of *Pinus nigra, Picea abies, Cupressus sempervirens*, and black locust *Robinia pseudacacia* stands. Potential predators co-inhabiting this area are the red fox *Vulpes vulpes*, beech marten *Martes foina*, weasel *Mustela nivalis* and badger *Meles meles*. Besides hunting dogs and shepherd's dogs, other animals in this area are feral cats *Felis silvestris catus* and dogs *Canis familiaris*. Herds of cattle, horses, sheep and goats graze freely during the entire year. Poaching also oc-curs within this protected area.

Abundance index

An abundance index of brown hares in our study area before and during our study, was calculated using a net census and a line of several beaters in two sample areas of 15 ha each (see Pielowski 1969). Censuses were performed four times during the study period, once each season. One sample area consisted of grassy pasture (30%) and shrubland (70%), the other of bushy pasture (50%), coppice forest (28%), and rocky pasture (22%). The censuses were conducted within a 150 x 1,000 m area, covered by 35-40 walking persons, plus 6-8 persons walking the borders of the surveyed area. In all cases, two hares were recorded leading to an average hare abundance of approximately 13 animals/100 ha. This density of hares is lower than previously reported for this area (e.g. see Pielowski & Pucek 1976, Meriggi & Verri 1990).

Source, animals and telemetry methods

Captive-bred hares were obtained from the 'Amministrazione Provinciale di Roma', and released in different periods of the year (for details see Angelici 1995). Forty-four adult hares (20 males, 24 females) were marked with radio-transmitters each weighing 30 g (Biotrack TW-3). All hares monitored during our study were released without a pre-releasing period. The radio-marked hares were monitored from the release date to the date on which death occurred or until monitoring ceased (for details see Angelici 1995). The location and activity type of each hare were recorded on average once every 11 hours by means of single signal locations. Signal locations were taken over a 24-hour period. Hare positions were estimated using the signal bearing triangulation method (Mech 1983), and indicated on a topographic map with a 62.5 m grid. Activity/inactivity was recorded by observing the movement of the oscillator pointer of the radio-receiver (Custom CE 12 and A.T.S. R1600; see Mech 1983). Radio-tracked hares were recorded as inactive if no activity was displayed during at least 120 seconds of continued monitoring. Positions were recorded once every 11 hours following the third day after release because data recorded during the first two days could be affected by stress following the release into a novel environment. In addition, continuous monitoring lasting 24 or 48 hours (with one fix every 15 minutes) was done once every 25-30 days. Hares were released in the morning between 07:00 and 08:00. In most cases only a single animal was released but occasionally 1-3 hares were released simultaneously. Releases were carried out throughout the year (Table 1).

Mortality was recorded in 38 hares (18 males, 20 females); we lost radio-contact with three hares, and three were still alive at the end of the study. The causes of death were identified by examination of hare remains found in the field (Reynolds & Tapper 1989, Dolbeer, Holler & Hawthorne 1994). When death seemed due to health deficiency, hare remains were collected for veterinary inspection at the 'Istituto Zooprofilattico Sperimentale del Lazio e Toscana'. To distinguish between predation and scavenging, the two following criteria were used: (i) the hare had marks of aggression in the neck or on the radio-collar (Dolbeer et al. 1994), or (ii) the aggression was directly observed.

Table 1. Telemetry data on sex, body mass/weight, survival and maximum distance moved from the release site for 44 radio-monitored brown hares studied in a mountain site in central Italy during 1992-1994.

Hare #	Sex	Mass (kg)	Survival (days)	Maximum distance (m)
1987	♂	3.300	12	259
1525	♀	3.300	212	462
1501	♀	3.300	5	226
1997	♂	3.300	7	504
1959	♂	3.300	1	312
1541	♀	3.300	2	280
1549	♀	3.300	3	225
1566	♀	3.750	75	225
1983	♂	3.250	112	260
1511	♀	3.500	248	802
1955	♂	3.500	12	474
1976	♂	3.200	7	398
1012	♀	3.300	284	489
1940	♂	3.000	12	140
1531	♂	3.300	264	1263
1508	♀	2.600	4	594
1560	♀	4.000	6	265
2000	♂	3.100	5	2809
1988	♂	3.150	120	1266
1982	♂	3.700	6	177
1100	♀	2.700	2	177
1561	♀	3.300	6	88
1529	♀	3.100	2	225
1548	♀	2.700	3	312
1550	♂	3.000	4	566
1044	♀	2.600	1	319
1584	♀	2.300	9	312
1551	♀	2.300	1	988
1562	♂	2.700	4	576
1592	♀	3.300	1	619
1969	♂	2.400	1	62
1555	♀	2.900	1	1002
1966	♂	3.000	6	442
1588	♀	3.200	1	380
1557	♂	3.400	3	763
1543	♀	3.600	3	884
1903	♂	3.500	1	929
1544	♀	3.100	332	619
1918	♂	3.400	30	1070
1554	♀	3.600	78	1002
1936	♂	2.800	244	1152
986	♂	3.200	203	625
1558	♀	1.400	2	265
1580	♀	2.100	139	750

Statistical analysis

Statistical analyses (two-tailed tests, alpha set at 5%) were done in accordance with Sokal & Rohlf (1981) and Siegel & Castellan (1992), using STATISTICA and SPSS (version 4.5 for Windows) PC packages. Dispersal rates were analysed by measuring the maximum linear distances from the release site (e.g. see Swihart & Slade 1983).

Results

Survival time and causes of death

We released 44 hares in the study area, of which 38 died before our field studies ended (see Table 1). Of the 38 hares, 26 (68,4%) died within 10 days after release, three (7.9%) within 11-20 days and one (2.6%) within 21-30 days, and eight (21.0 %) died more than 30 days after release. Mortality rates observed between time intervals were significantly different (Wilcoxon test: $Z = 7.371$, $P < 0.007$), whereas mortality rates between sexes did not differ (Wilcoxon test: $Z = -0.3651$, $P = 0.7150$). The average survival time was 59.9 days ($SD = 97.5$) but the survival time between males ($\bar{x} = 52.7$ days, $SD = 86.9$, $N = 20$) and females ($\bar{x} = 66.76$ days, $SD = 108.4$, $N = 21$) did not differ significantly (Mann-Whitney U-test, $U = 192.5$, $P > 0.1$).

Most of the hares were killed by natural predators, especially red fox (39.5%) and beech marten (10.5%), but 10 hares (26.3%) were killed by unknown predators. Additional causes of death were coccidiosis (5.3%), other diseases (5.3%), and unknown reasons (2.6%); other hares (10.5%) simply disappeared. Necropsy showed that one animal died from haemorrhagic tracheitis with associated bilateral lung congestion, and that another animal died of haemorrhagic catarrhal enteritis in the small intestine, associated with haepatic degeneration with parenchyma congestion. Predation was the main cause of death of radio-marked hares ($\chi^2 = 29.42$, df = 6, $P < 0.001$).

Dispersal

Most (97.5%, N = 41) of the radio-marked hares moved away from the release site; 16 hares moved 0-400 m, 13 moved 400-800 m, eight moved 800-1,200 m, three moved 1,200-1,600 m and one moved 2,809 m. There was no effect of survival time on dispersal rates (Spearman rank correlation: r=0.19, N=41, $P > 0.2$). This result depended only on hare # 2000 (survival: 5 days; dispersal: 2,809 m), which was a statistical outlier. When excluding this hare, and using a one-sided test of the null hypothesis, the results show a correlation between increasing survival and increasing dispersal movements (Spearman rank correlation: r = 0.25, $rs * (N-1)^{0.5} \cong N(0,1)$, P = 0.05). Moreover, there was no difference in the maximum distance moved by the sexes (Mann-Whitney U-test: U = 176.5, $P > 0.05$). The maximum distance from the release site tended to be positively correlated with the mass of hares: for hares dying within the first week after release, survival time increased with mass (P = 0.059, N = 27), while no such relationship was found for the more long-lived specimens (P = 0.93, N = 17).

Discussion

Survival time

Despite the fact that our translocation study is the only one that has been conducted in mid-elevation mountains (e.g. Pieloswki 1972, Fiechter 1988), our data still show that the mortality of captive hares was very high during the first days after release, especially during the first 10 days. Translocated hares are already known have a much lower survival rate than wild animals (monthly survival rate of our captive-bred sample is 0.30; average annual survival rates of wild specimens range within 0.4-0.6).

Causes of death

Our data on the causes of mortality of radio-marked brown hares were in general agreement with previous studies (Lindstrom, Andrén, Angelstam & Widén 1986, Reynolds & Tapper 1989, Goszczynski & Wasilewski 1992). The main hare predator in this study (the red fox) has been shown to strongly influence free-ranging hare populations in different areas (Goszczynski, Ryszkowski & Truszkowski 1976, Pielowski 1976, Lindström, Andrén, Angelstam & Widén 1986, Reynolds & Tapper 1989, 1995a, 1995b, Goszczynski & Wasilewski 1992).

The hares that died of coccidiosis and other diseases did so after just a few days following release, which suggests that they probably contracted these diseases when they were held in captivity. Moreover, it is likely that a negative interaction of various factors (post-release stress, diseases, starvation, predation) could be responsible for the low survival of translocated captive-bred hares.

Dispersal

Our data on average dispersal rates are in accordance with those reported earlier by Benmergui, Reitz & Fiechter (1990) and Marboutin, Benmergui, Landry & Fiechter (1991), whereas they conflict with those reported by Fiechter (1983, 1986) and Pépin & Cargnelutti (1987), who reported significantly higher dispersal distances. We suggest that a likely explanation for the different results of our study and some of the earlier studies may be that these were carried out in areas which were different from our study area, i.e. lowland and mainly cultivated sites. Pépin & Cargnelutti (1985) recorded mean dispersal distances of approximately 3,000 m for adult and 700 m for juvenile hares (2-4 months age). Zanni, Benassi & Trocchi (1988) found a mean dispersal distance of 284 m, which was similar to that reported by Douglas (1970) for New Zealand. Such a remarkable difference in dispersal distances is likely explained by different methods being used in the studies as well as a difference in the natural density of hares present prior to translocation (Jezierski 1968). In our study, the natural density of hares (see Material and methods) was low (see also Angelici 1995).

In summary, our data suggest that translocation of captive-bred hares is a weak conservation method, because of high mortality rates within a short time after release. Future studies should analyse the efficacy of translocation of wild captured hares from areas showing similar genetic structure.

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