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The process of dispersal in badgers *Meles meles*

T. J. ROPER, J. R. OSTLER and L. CONRADT
School of Biological Sciences, University of Sussex, Brighton BN1 9QG, UK

ABSTRACT

1. Radio-telemetry was used to track dispersal in five adult Eurasian badgers *Meles meles* (four males and one female) from three social groups.

2. All animals moved to a territory immediately neighbouring their home territory. Three of the males dispersed simultaneously as a 'coalition'; the other two individuals dispersed solitarily.

3. The process of dispersal took from 2 to 9 months. Dispersing animals first made nocturnal forays into the new territory but returned to their own territory to sleep. They then began to sleep progressively more often in setts in the new territory, and less often in their original territory. During this period, dispersers foraged in both the old and the new territory, before eventually settling into a home range centred exclusively on the new territory.

4. We conclude that dispersal can be a lengthy and complex process, even when the distance involved is small.

Keywords: exploration, ranging behaviour, sett use

INTRODUCTION

Dispersal is one of the most critical events in the lives of most individual animals and one of the most important processes affecting the ecology and evolution of populations. For example, dispersal affects the dynamics and persistence of populations, the distribution and abundance of species, community structure, gene flow, local adaptation, speciation, and the evolution of life-history traits (e.g. Greenwood, 1978, 1980). However, since most empirical data on dispersal are derived from capture-mark-recapture studies, little information is available about the act of dispersal itself; that is, about how dispersing animals select a target destination, how they get there, and how they settle in once they have arrived.

Here, we present detailed observations of dispersal in five adult European badgers *Meles meles*. We relate the results to the existing literature on dispersal in this species and also to prevailing views about how animals in general disperse.

METHODS

The study was carried out between January 1990 and December 1992 in a 2-km^2 area of the South Downs near Lewes, East Sussex, UK. The habitat consisted mainly of arable crops (68%), permanent pasture (29%) and scrub (2%), in a landscape of low chalk hills supporting a badger population of 16.5 adults/km^2 (see Butler, 1995 for details). Observations focused on five social groups (A–E) with contiguous territories, containing a total of 25 adult badgers and 10 cubs (Table 1). Fourteen of the adults were radio-collared, and were followed on foot

Correspondence: T. J. Roper. E-mail: T.J.Roper@sussex.ac.uk

Group	Adults		Cubs	Outlier setts	Territory size (ha)
	Female	Male			
A	3 (1)	4 (3)	2	1	19
B	2 (2)	1 (0)	1	1	14
C	2 (1)	1 (0)	2	2	21
D	4 (3)	3 (1)	1	4	27
E	3 (1)	2 (2)	4	3	20

Table 1. Characteristics of the social groups and their territories prior to the dispersal events described in the text (number of radio-collared adults in each group is shown in brackets)

and observed from close range for an average of 29.25 hours (range 16.25–33.75 hours) per badger per month using night-vision equipment. At the time of capture, tooth wear was recorded on a five-point scale, general body condition was recorded on a three-point scale, and presence of bite wounds was noted. In addition, all setts in the area were visited during the day to determine the daytime sleeping locations of the radio-collared animals, on an average of 18 days (range 15–22 days) per month. Territory boundaries were determined using information from bait-marking (Kruuk, 1978) carried out in April and November each year, together with monthly surveys of boundary paths and latrines (see Roper, Shepherdson & Davies 1986; Roper *et al*., 1993).

RESULTS

Five radio-collared adults (four males and one female), plus one cub that was not radio-collared, moved permanently from one social group to another. One male (D1) moved from group D to group E in 1990; three males (A1, A2 and A3) from group A to group C in 1991–92; and one female (B1), plus an accompanying cub, from group B to group A in 1991–92. Tooth-wear scores were two for A1, A2 and A3, three for D1, and five for B1, indicating that the dispersing animals varied considerably in age. The female, B1, was known to have bred successfully for two successive years prior to dispersal, and bred successfully in the year following dispersal.

In all cases, dispersal was to an adjacent territory. Nevertheless, data on daytime sleeping locations reveal that dispersal was a gradual process in which dispersing individuals moved backwards and forwards between the two relevant territories and their setts for periods ranging from 2 to 9 months (see Fig. 1 for examples). During these transitional periods, visits to the new territory were usually relatively short: the number of consecutive days spent sleeping in the new territory on any one visit averaged 4.7 days (range 1–18 days).

Four of the five dispersing animals used an outlier in their new territory for daytime sleeping purposes, in addition to the relevant main sett (Fig. 1). Three of these animals used the outlier only during the transitional period, after which they resided permanently in the new main sett. One disperser (D1), however, continued to use both the main sett and an outlier in its new territory for as long as observations continued (i.e. from October 1990 until December 1992).

During the transitional period, dispersing animals routinely foraged in both their old and their new territory, before finally settling into a home range centred exclusively on the new territory. For example, A3 occupied a home range centred on territory A until June 1991 but was seen foraging in territory C from July 1991 onwards (Fig. 2, top left). He continued to use both territories until December 1991 (Fig. 2, bottom left), after which his home range became restricted to territory C (Fig. 2, bottom right). Comparison of Figs 1 and 2 shows that although this animal started to make nocturnal visits to the new territory in July 1991

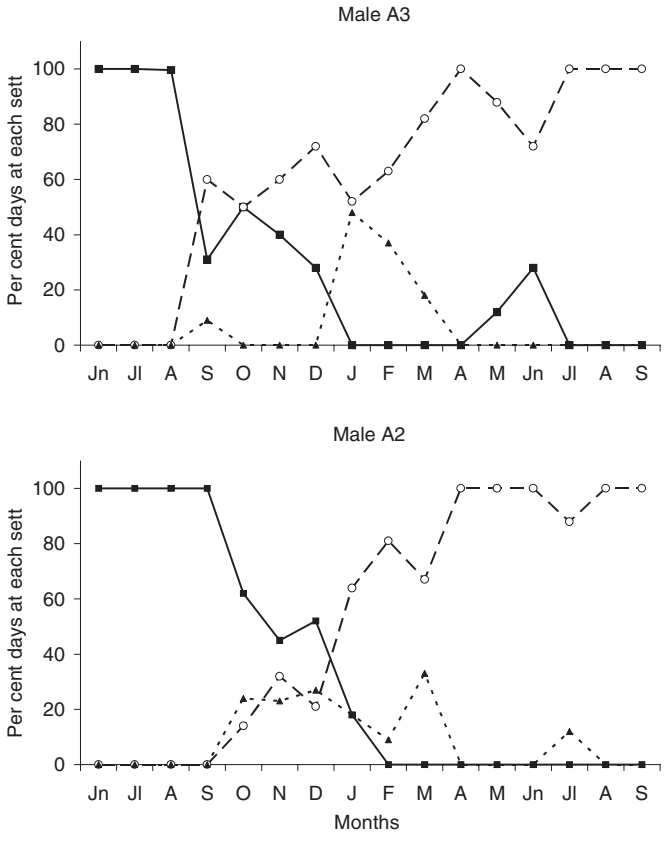

Fig. 1. Percentage of days per month that two dispersing male badgers (A3 and A2) spent in main sett A (filled squares), main sett C (open circles) and an outlier sett in territory C (filled triangles) during the process of dispersal from territory A to territory C. Results span the period from June 1991 to September 1992.

(Fig. 2), he was not recorded sleeping in a sett in territory C until September 1991 (Fig. 1). A similar pattern, whereby the animal in question began to make nocturnal forays into its new territory some weeks before changing its daytime sleeping location, was observed in all five dispersing adults.

Prior to dispersal, all animals were judged to be in good body condition except for the female (B1), which was noticeably thin. None had evidence of recent bite wounds. During transitional periods, when the animals in question were utilizing two territories and coming into close contact with members of both social groups, we saw no direct aggression involving dispersing individuals.

DISCUSSION

Previous studies of dispersal in badgers, based largely on capture-mark-recapture data, have shown that dispersal is relatively rare in high-density populations; is more frequent in males than in females; involves animals of all age classes; usually entails movement to a neighbouring territory; and does not appear to involve the disperser being forcibly driven from its original social group (Cheeseman *et al*., 1988; Woodroffe, Macdonald & da Silva, 1993; Christian, 1994; Rogers *et al*., 1998). Our results are consistent with all of these findings. However, whereas most previous studies have reported that males disperse solitarily, we observed an instance of three males from the same group dispersing together. Thus males can form dispersal 'coalitions' similar to those reported previously by Woodroffe *et al*. (1993) in female badgers. Simultaneous inter-group movements by more than one male were also

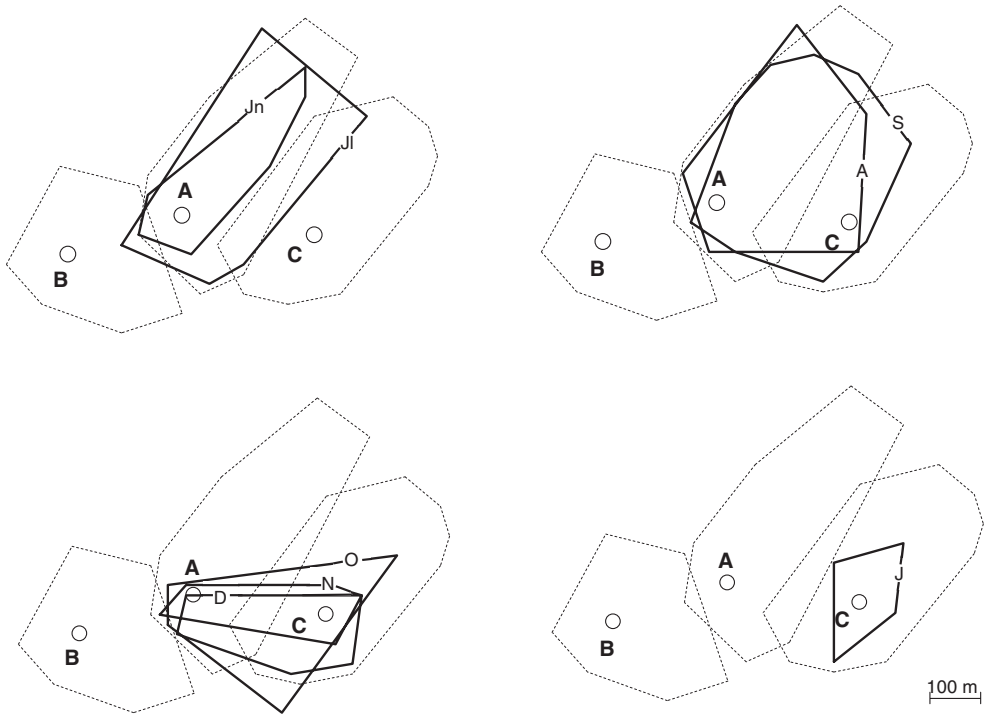

Fig. 2. Home range of a single male badger (A3) during dispersal from territory A to territory C. Dashed lines show the territory boundaries of three adjacent territories (A, B and C). Circles show the locations of corresponding main setts. Solid lines show the home range of A3 in each month from June 1991 (top left) to January 1992 (bottom right).

reported by Rogers *et al*. (1998) but they did not distinguish between dispersal and shorter-term movements.

Within the more general context of animal dispersal, the results are of interest because they show that dispersal can be a complex and protracted process, even when the distances involved are small (in this case, all movements were to an immediately adjacent territory). Most ecologists assume that dispersal is an all-or-none event in which the dispersing individual sets out at random to seek a new home, and either discovers a suitable location by chance or dies in the attempt (for reference, see Conradt *et al*., 2000; Conradt, Roper & Thomas, 2001). By contrast, intuitive reasoning, theoretical models and empirical evidence suggest that the chances of dispersing successfully might be improved by acquiring information about the surrounding environment prior to making a dispersal attempt (Conradt *et al*., 2000, 2001; Schjorring, 2002). Our badgers seem to have adopted this strategy, since they began to visit the target territory at night some weeks before taking up daytime residence in a new sett. In addition, other studies have shown that badgers routinely make short-term visits (lasting from a few minutes to a few days in duration) to neighbouring territories and setts (Cheeseman *et al*., 1988; Sleeman, 1992; Christian, 1994; Ostler, 1994; Rogers *et al*., 1998). Although such excursions are probably mainly concerned with foraging or exploiting mating opportunities (Christian, 1994), they may provide information relevant to future dispersal. Badgers probably also gain more or less continuously updated information about the composition of neighbouring groups by investigating olfactory signals deposited at boundary latrines, which have the potential to provide detailed information about territory occupants (Roper *et al*.,

1986; Roper & Lüps, 1993). Thus, dispersal attempts by badgers are probably very well informed.

As well as inspecting the target territory in advance, our animals also underwent a lengthy transitional period in which they utilized both their old and new territories and setts, possibly in order to keep open the option of returning to their original social group. How they managed to do this, without apparently attracting aggression from the members of either group, remains to be determined (see also Christian, 1994).

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REFERENCES

Butler, J. (1995) *The ecology of burrowing and burrow use in the European badger,* Meles meles. DPhil Thesis. University of Sussex, UK.

Cheeseman, C.L., Cresswell, W.J., Harris, S. & Mallinson, P.J. (1988) Comparison of dispersal and other movements in two badger (*Meles meles*) populations. *Mammal Review*, **18**, 51–59.

Christian, S.F. (1994) Dispersal and other inter-group movements in badgers, *Meles meles*. *Zeitschrift für Säugetierkunde*, **59**, 218–223.

Conradt, L., Bodsworth, E.J., Roper, T.J. & Thomas, C.D. (2000) Non-random dispersal in the butterfly *Maniola jurtina*: implications for metapopulation models. *Proceedings of the Royal Society of London, Series B*, **267**, 1–6.

Conradt, L., Roper, T.J. & Thomas, C.D. (2001) Dispersal behaviour of individuals in metapopulations of two British butterflies. *Oikos*, **95**, 416–424.

Greenwood, P.J. (1978) Functions of dispersal in birds and mammals. DPhil Thesis. University of Sussex, UK.

Greenwood, P.J. (1980) Mating systems, philopatry and dispersal in birds and mammals. *Animal Behaviour*, **28**, 1140–1162.

Kruuk, H. (1978) Spatial organisation and territorial behaviour of the European badger *Meles meles*. *Journal of Zoology, London*, **184**, 1–19.

Ostler, J.R. (1994) Sett use and sett function in the European badger. DPhil Thesis. University of Sussex, UK.

Rogers, L.M., Delahay, R., Cheeseman, C.L., Langton, S., Smith, G.C. & Clifton-Hadley, R.S. (1998) Movement of badgers (*Meles meles*) in a high-density population: individual, population and disease effects. *Proceedings of the Royal Society of London, Series B*, **265**, 1269–1276.

Roper, T.J., Conradt, L., Butler, J., Christian, S.E., Ostler, J. & Schmid, T.K. (1993) Territorial marking with faeces in badgers (*Meles meles*): a comparison of boundary and hinterland latrine use. *Behaviour*, **127**, 289–307.

Roper, T.J. & Lüps, P. (1993) Disruption of territorial behaviour in badgers *Meles meles*. *Zeitschrift für Säugetierkunde*, **58**, 252–255.

Roper, T.J., Shepherdson, D.J. & Davies, J.M. (1986) Scent marking with faeces and anal secretion in the European badger. *Behaviour*, **97**, 94–117.

Schjorring, S. (2002) The evolution of informed natal dispersal: inherent versus acquired information. *Evolutionary Ecology Research*, **4**, 227–238.

Sleeman, D.P. (1992) Movements in an Irish badger population. In: *Wildlife Telemetry* (Ed. by I.G. Priede & S.M. Swift), pp. 670–676. Ellis Horwood, Chichester, UK.

Woodroffe, R., Macdonald, D.W. & da Silva, J. (1993) Dispersal and philopatry in the European badger, *Meles meles*. *Journal of Zoology, London*, **237**, 227–239.

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