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What do European badgers (*Meles meles*) know about the spatial organisation of neighbouring groups?

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Abstract

European badgers (*Meles meles*) live in groups. Although they can distinguish between a member of their own group, a member of a neighbouring group and a stranger, their ability to understand that neighbouring individuals belong to different groups inhabiting different places, and possibly to build up some representation of the spatial organisation of neighbouring groups remains to be shown. In this study, we conducted a pilot homing experiment to test such ability. Radio-collared badgers were displaced to the home ranges of neighbouring groups and their homing performances were compared to those of badgers displaced either to the periphery of their own group's home range or beyond the neighbouring home ranges. When released in their own home range, badgers homed rapidly and efficiently, whereas when released beyond the neighbouring groups' home ranges (whatever the distance) they did not home. In contrast, badgers released in the home range of a neighbouring group performed some random search there, before returning to their setts quite efficiently. These results suggest that badgers may consider their neighbours as members of different groups inhabiting different places close to their own home range, but their ability to build up some spatial representation of neighbourhood relationships could not be demonstrated.

Keywords: European badger; Homing; Home range; Cognitive mapping; Neighbourhood

1. Introduction

Although there have been numerous field studies focusing on habitat use and spatial organisation in wild mammals (for the European badger, *Meles meles*, see Cresswell and Harris, 1988; Da Silva et al., 1993; Do Linh San, 2002; Feore and Montgomery, 1999; Revilla and Palomares, 2002), a related question that has never been addressed is what the individuals themselves know about this spatial organisation. The importance of this type of question has been emphasised since the role of cognition in evolutionary ecology was acknowledged (e.g. Real, 1994). Spatial cognition has been widely studied in mammals, in particular in the Norway rat (*Rattus norvegicus*) but almost exclusively in laboratory conditions, using artifactual protocols that may have low ecological relevance (review in Poucet and Benhamou, 1997). In contrast, we attempted here to get some insights about spatial cognition of wild mammals in their natural environment by means of a homing experiment (translocation) on the European badger.

Field experimental translocations are generally performed to study orientation abilities. In this way, numerous experiments have been performed in birds, usually able to home from very distant release sites (see reviews by Wiltschko and Wiltschko, 2003, and Wallraff, 2004), and a few experiments have been performed at a shorter scale on small mammals, usually unable to home from distant release sites (see review in Bovet, 1992). Some large-scale translocations of wild large mammals have also been performed for conservation and/or management purposes, assuming that the individuals will settle in the vicinity of the release site rather than return to their previous homes (Nielsen, 1988; Rogers, 1988; Bradley et al., 2005). The purpose of the short-scale homing experiments we performed on badgers was quite different, as we used translocation to determine to which extent badgers are able to build up some spatial representation of neighbourhood relationships.

The European badger is a nocturnal carnivore living in territorial groups of related individuals and showing high fidelity to its native home range (Kruuk, 1978a, 1989; Kruuk and Parish,

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1982; Roper et al., 1986; Cheeseman et al., 1988; Evans et al., 1989; Woodroffe and Macdonald, 1993; Woodroffe et al., 1995). The members of a group share a main communal sett for daily resting and breeding, and more occasionally use other, secondary setts (Roper, 1992; Roper and Christian, 1992). Like most terrestrial mammals, badgers may get accustomed to the smells of other badgers living with them or in their neighbourhood (Stewart et al., 2002; Frommolt et al., 2003), and hence may have some knowledge about the spatial organisation of neighbouring groups. Three knowledge levels in the cognitive abilities may be broadly distinguished. At the basic knowledge level, a badger may realise that any given scent mark it encounters was made by a member of its own group (including itself), a member of a neighbouring group or a stranger, but it cannot discriminate between the different neighbouring groups. At the intermediate level, the badger may be aware that the neighbouring badgers belong to different groups inhabiting different places, because the neighbours' familiar scent marks it encounters are different when it moves in the northern, southern, eastern or western periphery of its home range, but it remains unable to encode the relative spatial relationships between the different neighbouring groups. In our view, such an ability to build up some cognitive mapping of the spatial organisation of the neighbourhood characterises the highest knowledge level.

The homing experiment we performed consisted in releasing a badger in the home range of a given neighbouring group and in determining how efficiently it is able to home, i.e. to return to its group's main sett. We indeed assumed that a translocated badger tends not only to return to its home range, but also to shelter as quickly as possible in its group's main sett. This assumption proved correct as even "control" badgers, released within their group's home range showed a strong motivation to return to their main sett (see below). If badgers have no knowledge of their neighbourhood (i.e. all badgers except the members of their own group are considered as strangers), the translocated individual will wander about from the release site and hence will get lost rapidly or will find its way home merely by chance. The basic and intermediate knowledge levels will enable the displaced individual to restrict its random search to a particular area, until it reaches its own home range by chance. They introduce increasing spatial constraints on the random search, which becomes more likely to target a familiar place quickly. With the basic knowledge, the restricted area corresponds to the set of home ranges occupied by the neighbouring groups. With the intermediate knowledge, the restricted area will be narrower, as it will correspond to the home range of the neighbouring group where the displaced individual was released. Finally, if badgers have access to the highest knowledge level, the released individual will be able to home even more efficiently thanks to its spatial representation of the neighbourhood.

To be fully appreciated, the homing performances of the badgers displaced in a neighbouring group's home range should be compared to those of badgers released at the periphery of their own home ranges, at roughly similar distances. Furthermore, it cannot be a priori ruled out that translocated animals might rely on some local or long-distance environmental gradient fields to determine their home direction (Jamon and Bovet, 1987; Jamon and Benhamou, 1989). If so, the badgers released in a neighbouring group's home range would be able to home fairly efficiently even with no knowledge of the neighbouring groups. To test that, we released two badgers just beyond the neighbouring groups' home ranges and two other badgers far from their home ranges.

2. Materials and methods

The field study was carried out from May 2003 to November 2004 in the "Croix-aux-Bois" forest, a 3300 ha hardwood area surrounded by pastures in the Ardennes, a rural region in the northern-eastern part of France. Badgers belonging to three neighbouring groups were caught in baited cage traps (115 cm × 35 cm × 35 cm) placed near the main setts. Trapping took place all over the year, except very cold nights. Captured adults and subadults were anaesthetised by an intramuscular injection of 15–25 mg/kg of ketamine hydrochloride (Imalgene^{TM}) and were fitted by 150 g (ca. 1.5% of the body mass) Televilt^{TM} radio-collars with activity sensors. They were radio-tracked from vehicles equipped with 3-m high Yagi antennae. Long periods of immobility were considered as resting periods and the radio-collared badgers resting regularly in the same main sett were considered as belonging to the same group (Harris, 1982; Wilson et al., 2003). Individual home ranges were estimated using the 95% fixed kernel method (using ArcView; see http://www.esri.com/) from the 10 to 15 independent radio-locations (spaced out by at least 2 h) recorded each month for each badger during activity periods. Each radio-location was obtained by triangulation based on three successive compass bearings obtained by only one person in about 10 min. Badgers with less than 50 radio-locations (i.e. surveyed for less than 3–4 months) were not taking into account, in agreement with Seaman et al. (1999)'s recommendations for kernel home range estimations. The groups' home ranges were defined as the whole areas occupied by all the collared members of a same group.

The experiment involved five different conditions. Three types of translocation were performed on the badgers inhabiting Croix-aux-Bois forest. Translocated badgers were trapped one more time and released at night at some distance from their home. For such individuals, the release site was at the periphery of their own group's home range in the "control" condition, within the home range of a neighbouring group in the "neighbour" condition, or just beyond the neighbouring groups' home ranges in the "outside" condition. The displacement distances used in the "control" and "neighbour" conditions were similar, and slightly greater in the "outside" condition (Table 1). Moreover, we recorded normal foraging activities, starting and ending at their home. In this "natural" condition, we defined the "homing path" as the last part of the loop, starting at the farthest location from the home. A fifth, "far" condition concerned two male badgers, one adult and one subadult, originally living about 60 km west from Croix-aux-Bois forest. These two individuals should initially have been killed during hunting sessions organised to protect cultures from badger damages. We managed to catch them alive, and we radio-collared them under anaesthesia just after capture and released them at night the day after in our study area. As in the "outside" condition, these two badgers