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Fluorescent powder as dye in bait for studying foraging areas in small mammals

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We examined the characteristics of fluorescent powder as dye in bait for the purpose of studying individual foraging areas of the root vole *Microtus oeconomus* (Pallas, 1776). Colours were visible in the faeces 2–3 h after consumption, and were still evident 36–48 h after the removal of bait. It was possible to distinguish up to four different colours in faeces from one individual if the appropriate combination of coloured powder was used. The method is a better alternative to other markers commonly used in bait because only a small extra sampling effort is needed during trapping, and the observation of colours is relatively easy in UV-light. Because the persistance of the colour powder in the animal is relatively short, the method facilitates studies of short-term changes in foraging areas.

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Introduction

Home range estimates of small mammals are frequently based on data collected by radiotracking or capture-recapture techniques without any direct observation of behaviours (Andreassen *et al.* 1993). Except for social interactions estimated from home range overlap (eg Andreassen and Ims 1990, Lambin *et al.* 1992), there has been a general lack of attempts to determine the types of small mammal behaviours performed in different parts of the home range (but see Getty 1981, Price *et al.* 1986). Information about the connection between behaviour and space use would greatly improve the application of the home range concept (*sensu* Burt 1943) in ecological studies. Unfortunately this connection is currently poorly developed, especially for species with cryptic behaviour (eg most small mammals).

Here we suggest a modified way of using dyed bait to study foraging ranges of small mammals. Although the methodology of marked bait has been applied for several decades in studies of space use, the aims of previous investigations have been restricted to research concerning long distance movements (Liro and Szacki 1987, Szacki and Liro 1991), or maximum traversed areas on the population level (New 1958, Frantz 1972) without any reference to individuals and their behaviour.

Furthermore, the methods commonly used have been hampered by artificial settings, such as the release of animals prefed with marked bait in the laboratory (Randolph 1973), by the use of markers which persist in the intestines for some time (Haresign 1959, Adamczyk and Ryszkowski 1968, Holisová 1968, Ryszkowski 1971, Randolph 1973) which complicates the observation of short-term changes in foraging areas, or by analysing the alimentary canals of dead animals (Ryszkowski 1971, Andrzejewski and Babińska-Werka 1986). Some of the methods have also been troublesome due to concerns associated with handling of radioactive markers (Bailey *et al.* 1973, Stenseth and Lidicker 1992), or cumbersome due to the use of microscopy to identify markers (Liro and Szacki 1987, Szacki and Liro 1991).

We examined the feasability of using fluorescent pigments (Radiant Colour, Richmond, California) as labels in bait (see also Frantz 1972) in a laboratory setting, with the intention of using such bait in field studies of the foraging areas of individual root voles *Microtus oeconomus* (Pallas, 1776). For our purposes marked bait needed to: (1) be easily located in the field, (2) provide the possibility to distinguish a variety of colours, (3) be easily observable in fecal pellets collected from live traps, and (4) be persistant in the gut for a short time (few days) so that changes in foraging areas could be detected by removing and relocating new bait between trapping sessions.

With these intentions in mind we tested the following characteristics of the fluorescent powder: (1) the concentration of powder needed to make it visible in faeces, (2) the time period from when the bait was eaten until it was visible in the faeces, (3) the time period from removal of bait until the pigment was no longer visible in the faeces, and (4) the possibilities of observing a mixture of pigment colour in the faeces. The last aspect (4) was also considered in a field test using several colours of dyed bait simultaneously.

Methods and results

Laboratory tests

During each laboratory test a petri dish containing marked bait (100 g porridge consisting of 50% water, 25% cornmeal, 12.5% oats and 12.5% millets) was given to 12 individually caged adult non-pregnant female root voles. The animals originating from Pasvik, Finmark County, Norway were raised in the laboratory at the Animal Division, Department of Biology, University of Oslo. The same individuals were used in all laboratory tests. Before every experiment the cages were cleaned, and every day during the experiments (14 days totally) we estimated the proportion of marked bait eaten by each animal, collected 20 fecal pellets at random from each cage for examination, and removed all other fecal pellets.

Experiment 1: Three different concentrations of fluorescent powder (0.5 g, 1.0 g and 1.5 g per petri dish of porridge) were tested. All 12 animals (4 individuals on each concentration level) ate parts of the coloured bait, and the colours were

Table 1. The concentration of fluorescent powder needed to make it visible in faeces. Presented with concentration levels of dyed bait, n – number of animals given that concentration, average percent of bait eaten (of 100 g porridge given to each animal), and average percent of fecal pellets with colour observed under UV-light and normal room light at different time intervals post-consumption. The bait was removed after 36 h.

Concentration	n	% eaten	UV-light				Normal room light			
			24 h	48 h	72 h	96 h	24 h	48 h	72 h	96 h
Low	4	34.5	12.5	2.5	0		0	0	0	
Intermediate	4	44	26.3	5.6	0		1.9	0	0	
High	4	31	84.4	82.5	8.1	0	51.3	56.9	1.3	0

visible in the faeces 2–3 h post consumption. It was possible to observe colour in normal room light (high concentration), but substantially more fecal pellets were found to contain coloured pigment when exposed to UV-light (Table 1). Hardly any faeces examined from animals given low or intermediate concentrations of powder exhibited visible colour 12 h after removal of the bait, whereas faeces from animals given high concentrations of pigment exhibited colours 12 and 36 h after the removal of bait (Table 1).

Experiment 2: The visibility of 10 different fluorescent colours was tested by giving bait containing only one colour in high concentration (1.5 g per petri dish) to each of 10 animals. Bait was removed after 48 h (Table 2). Almost all faeces contained visible pigments 24 h after baiting, and a large proportion of the

Table 2. The visibility of the 10 different fluorescent colours given to each of 10 animals. Presented with percent bait eaten (of 100 g porridge) and percent of fecal pellets with colour visible under UV-light and normal room light at different time intervals post-consumption. The bait contained a high concentration of fluorescent powder (1.5 g per petridish) and was removed after 48 h. Colours indistinguishable under UV-light without the use of photographic filters are grouped.

Colour	% eaten	UV-light				Normal room light			
		24 h	48 h	72 h	96 h	24 h	48 h	72 h	96 h
Cerise	50	60	95	60	55	60	95	40	10
Pink	66.5	75	100	75	5	75	100	75	5
Magenta	50	100	100	75	5	100	100	50	5
White	66.5	70	95	45	0	70	80	35	0
Blue	100	90	100	85	5	90	90	50	0
Green	50	100	100	30	0	100	100	20	0
Yellow	33	75	100	50	0	75	80	15	0
Red	37.5	100	95	85	15	100	95	75	0
Sunset orange	50	100	100	65	0	100	100	35	0
Orange yellow	50	100	85	50	0	0	0	0	0

faeces still had detectable coloured powder 24 h after removal of bait. The variation in the proportion of faeces containing coloured powder was not correlated with the amount of bait eaten (all $r_S < 0.29$, all $p > 0.37$, Spearman rank correlation). Some colours (grouped in Table 2) were indistinguishable in UV-light without the use of photographic filters.

Experiment 3: We tested the possibility of detecting a mixture of colours in the faeces by giving animals bait containing 2–6 different fluorescent powders. It was possible to detect two, three and to some degree four colours if the combination included colours distinguishable under UV-light. We found the best combination to be orange yellow, blue, green and pink, that is, it was possible to observe all these colours in an individuals faeces using UV-light.

Field experiment

We supplied fluorescent powder in bait to seven enclosed populations of root voles at Evenstad Research Station, Østerdalen, South East Norway, through 5 experimental periods between early July and late October 1993 (see Ims *et al.* 1993 for further description of the study area). Each trap station contained an Ugglan multiple capture live trap, and the traps were kept activated from 04.00 h until 18.00 h (checked every 5 h) Mondays and Thursdays during the reproductive season. We placed one petri dish of dyed bait per 22.5 m^2 two days (Saturdays) before each trapping session. For every captured vole, faeces were collected and placed in separate plastic bags. Traps were cleaned to avoid colour contamination between different trapping events. Sampling of faeces was performed from all solitary individuals captured and not from multiple captures because it was impossible to identify from which individual the faeces belonged to. Four different colours, orange yellow, blue, green and pink, were tested. The bait remaining from one baiting trial was removed no later than one week before the next experiment. A large number of individual samples exhibited colour, and data for the first three experimental periods showed that 801 (85.2%) of the collections (940 totally) contained pigments. Of these 685 (72.8%) exhibited one colour, 105 (11.2%) two colours, 9 (1%) three colours and 2 (0.2%) four colours.

Discussion

We belive the use of fluorescent powder in bait in many cases is a better alternative to other markers for studying small mammal foraging areas. This is because only a small extra sampling effort is needed during trapping, and the observation of colours is relatively uncomplicated compared to methods which necessitate the autopsy of animals or require the use of microscope. Furthermore, fluorescent powder has some desirable characteristics in that it is visible in faeces a few hours after consumption, and passes completely through the intestine within a few days, characteristics which would facilitate studies on changes in foraging areas. The method tested in this study would be applicable both for identifying

the foraging areas within home ranges and foraging areas relative to features of habitat patchines. The technique is constrained by the number of colours which can be distinguished, but may be improved by applying photographic filters which absorb certain coloured light during examination with UV-light. Moreover, the bait itself may affect small mammal space use by acting as an attractant. This may be avoided by using a non-preferred bait, as well as by distributing the bait evenly and densely in small amounts throughout the study area. However, due to environmental contamination (Halfpenny 1992), application of fluorescent powder should be considered carefully.

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References

Adamczyk K. and Ryszkowski L. 1968. Estimation of the density of a rodent population using stained bait. Acta Theriologica 13: 295–311.

Andreassen H. P. and Ims R. A. 1990. Responses of female grey-sided voles *Clethrionomys rufucanus* to malnutrition: a combined laboratory and field experiment. Oikos 59: 107–114.

Andreassen H. P., Ims R. A., Stenseth N. C. and Yoccoz N. G. 1993. Investigating space use by means of radiotelemetry and other methods: a methodological guide. [In: The biology of lemmings. N. C. Stenseth and R. A. Ims, eds]. The Linnean Society of London, Academic Press, London: 590–614.

Andrzejewski R. and Babińska-Werka J. 1986. Bank vole populations: Are their densities really high and individual home range small? Acta Theriologica 31: 409–422.

Bailey G. N. A., Linn I. J. and Walker P. J. 1973. Radioactive marking of small mammals. Mammal Review 3: 11–23.

Burt W. H. 1943. Territoriality and home range concepts as applied to mammals. Journal of Mammalogy 24: 346–352.

Frantz S. C. 1972. Fluorescent pigments for studying movements and home ranges of small mammals. Journal of Mammalogy 53: 218–223.

Getty T. 1981. Territorial behaviour of eastern chipmunks (*Tamias striatus*): Encounter avoidance and spatial time-sharing. Ecology 62: 915–921.

Halfpenny J. C. 1992. Environmental impacts of powdertracking using fluorescent pigments. Journal of Mammalogy 73: 680–682.

Haresign T. 1959. A technique for increasing the time of dye retention in small mammals. Journal of Mammalogy 41: 528.

Holisová V. 1968. Marking small mammals by means of coloured admixtures to bait. Small Mammal Newsletter 2: 36–40.

Ims R. A., Rolstad J. and Wegge P. 1993. Predicting space use responses to habitat fragmentation: Can voles *Microtus oeconomus* serve as an experimental model system (EMS) for capercaillie grouse *Tetrao urogallus* in boreal forest? Biological Conservation 63: 261–268.

Lambin X., Krebs C. J. and Scott B. 1992. Spacing system of the tundra vole (*Microtus oeconomus*) during the breeding season in Canadas western Arctic. Canadian Journal of Zoology 70: 2068–2072.

Liro A. and Szacki J. 1987. Movements of field mice *Apodemus agrarius* (Pallas) in a suburban mosaic of habitats. Oecologica (Berlin) 74: 438–440.

New J. G. 1958. Dyes for studying the movements of small mammals. Journal of Mammalogy 39: 416–429.

Price K., Broughton K., Boutin S. and Sinclair A. R. E. 1986. Territory size and ownership in red squirrels: response to removals. Canadian Journal of Zoology 64: 1144–1147.

Randolph S. E. 1973. A tracking technique for comparing individual home ranges of small mammals. Journal of Zoology, London 170: 509–520.

Ryszkowski L. 1971. Estimation of small rodent density with the aid of coloured bait. Annales Zoologici Fennici 8: 8–13.

Stenseth N. C. and Lidicker W. Z., Jr 1992. The use of radioisotopes in the study of dispersal: with a case study. [In: Animal dispersal. N. C. Stenseth and W. Z. Lidicker, Jr, eds]. Chapman and Hall, London: 333–352.

Szacki J. and Liro L. 1991. Movements of small mammals in the heterogeneous landscape. Landscape Ecology 5: 219–224.

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