

Do Tengmalm's owls see vole scent marks visible in ultraviolet light?

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(Received 4 September 1996; initial acceptance 14 October 1996;
final acceptance 20 December 1996; MS. number: 5332)

Abstract. Scent markings (urine and faeces) of small mammals are visible in ultraviolet (UV) light. Diurnal kestrels, *Falco tinnunculus*, use them as a cue to find areas of food abundance. We studied whether vole-eating, nocturnal Tengmalm's owls, *Aegolius funereus*, can see vole scent marks using UV-vision. In a laboratory experiment, 14 young (less than 6 months old) and 14 adult (more than 6 months old) owls were individually given a choice between four adjacent arenas: (1) an arena with vole urine and faeces in UV light; (2) an arena with vole urine and faeces in visible light; (3) a clean arena in UV light; and (4) a clean arena in visible light. Owls did not prefer any of the four arenas. Our results suggest that Tengmalm's owls probably do not use UV light as a cue to detect vole scent marks.

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Pronounced oscillations in densities of small rodent populations are characteristic in northern Europe (Hansson & Henttonen 1985; Hanski et al. 1993). In the same region, densities of rodent-eating avian predators also vary dramatically and nearly synchronously with prey densities (Korpimäki 1985, 1994; Korpimäki & Norrdahl 1991). Crashes of rodent populations induce wide emigrations (>1000 km) of some avian predators (e.g. Andersson 1980; Korpimäki et al. 1987; Sonerud et al. 1988). However, until recently, it has been unknown how predators rapidly detect areas of rodent abundance without prior knowledge of their population fluctuation.

Small rodents mark their territories with urine and faeces (Rozenfeld et al. 1987), which are visible in ultraviolet (UV) light (<400 nm; Silverstein & Bassler 1965; Desjardins et al. 1973; Viitala et al. 1995). Viitala et al. (1995) recently demonstrated experimentally that wild European kestrels, *Falco tinnunculus*, can see vole scent marks, both urine and faeces, in ultraviolet light and use them as a cue of prey-patches in the field.

Although the UV-vision (320–400 nm) of diurnal birds is well established (Bennett & Cuthill 1994), there is little information on UV-sensitivity among nocturnal birds. The eyes of nocturnal birds are highly adapted to viewing in darkness, with a retina dominated by rods (Bowmaker & Martin 1978; Martin 1990). There is also evidence that the tawny owl, *Strix aluco*, possesses colour vision (Suthers 1978), but not UV-sensitive pigments (Bowmaker & Martin 1978). Potentially owls are still able to detect UV light with photopigments that have maximum absorption in the visible light range (Jacobs 1992).

The Tengmalm's owl, *Aegolius funereus*, is a common nocturnal bird of prey in the Holarctic coniferous forest belt, mainly north of 60°N (Mikkola 1983). Because Tengmalm's owls in Europe feed mainly on voles of the genera *Microtus* and *Clethrionomys* (Korpimäki 1981, 1987), whose cyclic numbers markedly affect the breeding density, reproductive performance and dispersal of the owls (Korpimäki et al. 1987; Korpimäki & Lagerström 1988), they should also benefit from locating patches with a high density of small mammals.

The hunting success of owls is best during clear nights (Clarke 1983; Kotler et al. 1988, 1991). Given that UV light is also present in the night sky (Roach & Gordon 1973), it is possible that nocturnal owls could use UV light when hunting,

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particularly in northern areas where summer nights are bright for several months. At least some of their nocturnal prey species may be UV-sensitive (Jacobs et al. 1991; Szél et al. 1992). We performed a laboratory experiment to investigate whether Tengmalm's owls can see vole scent marks in UV light.

MATERIALS AND METHODS

We captured 14 young (less than 6 months old) and 14 adult (from 7 months to more than 3 years old) Tengmalm's owls for this study. All young owls were taken in late May to early July 1993 as fledglings (25–28 days old) from the Kauhava study area (63°N, 23°E), western Finland (see Korpimäki 1994, and reared in captivity until they had completed their post-juvenile moult. We conducted the experiments when these owls were 4–5 months old. We trapped the adult owls in early October 1994 near Kokkola (64°N, 22°30'E), western Finland, during their autumn migration (see Sykkö & Vikström 1987). All the owls were released after the experiments, to the areas where they had been caught.

We performed laboratory experiments at the Konnevesi Research Station, central Finland, in August 1993 (young owls) and October 1994 (adult owls). The walls of the experimental room (5 × 4 × 2.5 m) were covered with black paper to exclude natural light and any other cues for orientation. The experimental room contained four adjacent sheet metal arenas, measuring 1 × 2 m, with hard brown cardboard floors and walls 50 cm high. The walls of the arenas were covered with brown paper. Above each arena there was a horizontal bar 1.7 m long bolted to the wall at a height of 1.8 m and a vertical pole 80 cm high on the floor of the arenas for the perching owls. The perch height in the experiment was near the normal perch height in the field.

We put field voles, *Microtus agrestis*, into two of the arenas (one male and two females in both arenas) for 17 h and removed them before the experiment. The other two arenas contained no voles. Reflection of vole scent marks on cardboard shows that there are contrasts in UV wavelengths that facilitate the detection of vole scent marks by a UV-sensitive spectator (Figure 1 in Viitala et al. 1995).

One arena that had contained voles and another arena that had not contained voles were illuminated with one 160 W black light UV-bulb (Philips MLW 160W; spectral energy distribution 366 ± 20 nm) each. The other two arenas were illuminated with one ordinary 60 W bulb (OSRAM 9W3, 60W, bulbs were emitting <1% UV light; irradiance spectra of UV- and ordinary bulbs in Figures 4a and 4b of Viitala et al. 1995). The four options for owls were: (1) vole trails (urine and faeces) in ultraviolet light; (2) clean arena (no vole trails) in ultraviolet light; (3) vole trails in visible light; and (4) clean arena in visible light. The sockets of the lamps were located 115 cm above the floor of the arenas.

Each owl was introduced individually to the arenas twice for 15 min with 48 h separating the two trials. We changed the positions of the arenas after each trial. The owls were not fed for 24 h before the exposure; therefore they were hungry and eager to hunt. Each trial was made in the evening, because Tengmalm's owls are nocturnal. We observed the owls' behaviour from a dark hide through a wire mesh window measuring 30 × 30 cm, with 1-mm openings so that the owls could not see the observer. We recorded the time the owl spent above each arena and the number of scans made to different arenas. As one scan, we counted an event when an owl directed its eyes to an arena and bobbed its head to estimate the distance to the target (Mikkola 1983; Viitala et al. 1995). The owls were housed in an unheated aviary, with shelter from wind and rain. The temperature in the aviary was the same as outside and the light:dark cycle was 19:5 h. Two owls were placed into each cage (bottom 1.6 × 2 m, height 2.2 m) of the aviary. The owls were fed daily (except for the day before the trial) on chicks (one chick/owl/day). The young owls were kept in captivity for 3 months as they were reared from fledglings. The adult owls were released after 3 weeks' captivity.

To see how much the irradiance varied in one area and to measure the light conditions in summer under which Tengmalm's owls in northern regions usually hunt, we measured spectral radiance over a period of 24 h at the Konnevesi Research Station in a small open area in July–August in 1995 and 1996. The spectra were measured with a calibrated EG&G Gamma Scientific Spectroradiometer GS3000 (Receptor 700-8D, 250–1700 nm; Coupler 700-3K, 250–880 nm;

Monochromator NM 5DH, 190–820 nm; Detector D-46CQ, 200–930 nm). The cosine diffusor was inclined about 20° towards the sky.

We compared the means of distributions in different behaviours of owls using repeated measures ANOVA (SPSS for Windows) after log-transforming the data. Treatment was used as a factor with four levels based on the a priori assumption that a combination of vole trails and UV light is the most effective cue for birds. We analysed age classes of owls separately. All statistical tests were two-tailed.

RESULTS

There was a wide variation in the spatial irradiance within a 24-h period. The amount of UV light (320–400 nm) in relation to visible light (402–700 nm) was larger at night, between 2230 and 0400 hours (mean 34.9%), than during the day, between 1000 and 1600 hours (mean 12.6%; Wilcoxon signed-ranks test: $Z = -3.059$, $N = 12$, $P = 0.002$; Fig. 1 shows an example for 1 day).

Adult owls tended to spend more time above the clean arena in visible light than above the other arenas (Fig. 2a), but the between-treatment difference was not significant ($F_{3,39} = 1.54$, NS). The time spent by young owls above arenas did not differ between treatments ($F_{3,39} = 0.44$, NS). Similarly, the number of scans did not differ between the treatments either in adult or in young owls ($F_{3,39} = 0.23$, NS; $F_{3,39} = 1.61$, NS, respectively; Fig. 2b).

DISCUSSION

Ultraviolet vision might be advantageous for owls in the wild because females could use it to find a suitable breeding area, and males might use it to search for food patches inside their home ranges and decide whether to breed. However, our results suggest that Tengmalm's owls do not rely on visual detection of vole scent marks when hunting under laboratory conditions.

This result is consistent with results from a previous study on the eye structure of nocturnal tawny owls where no UV-receptors were found (Bowmaker & Martin 1978). Our results also agree with Jacobs' (1992) prediction that nocturnal birds do not have ultraviolet vision. It is

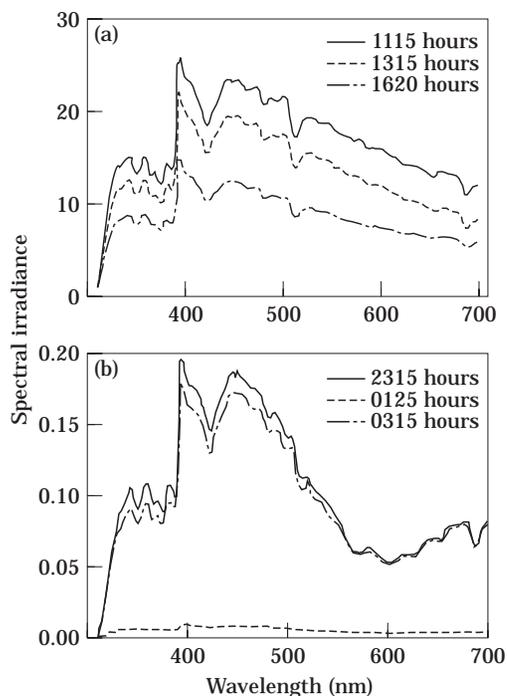


Figure 1. The spectral irradiance ($\mu\text{W}/\text{cm}^2 \times \text{nm} \times \text{sr}$) in a small open area measured at Konnevesi 13–14 July 1995, (a) during the day 1115, 1315 and 1620 hours; (b) at night 2315, 0125 and 0315 hours. Note the different scales on the Y-axes. Sunset was at 2249 and sunrise at 0355 hours. Civil twilight (sun 6° below horizon) ended ca 0125 and started again at 0140 hours.

unlikely that we failed to detect UV-sensitivity in Tengmalm's owls as a consequence of laboratory artefacts, because we used the same experimental protocol and room where diurnal kestrels preferred to hunt on an arena with vole urine and faeces in UV light (Viitala et al. 1995). The experimental situation was not unnatural, as wild Tengmalm's owls sometimes hunt inside small buildings in both winter and summer (Korpimäki 1981). The prey choice of Tengmalm's owls has also been studied in an aviary where they willingly hunt voles (V. Koivunen, E. Korpimäki & H. Hakkarainen, unpublished data).

Tengmalm's owls begin to hunt after sunset and end before sunrise, even during the short summer nights in northern areas (Klaus et al. 1975; Korpimäki 1981). Their pause–travel strategy, searching for prey from perches approximately 1.7 m above the ground and striking the prey from a mean distance of about 5 m, suggests that

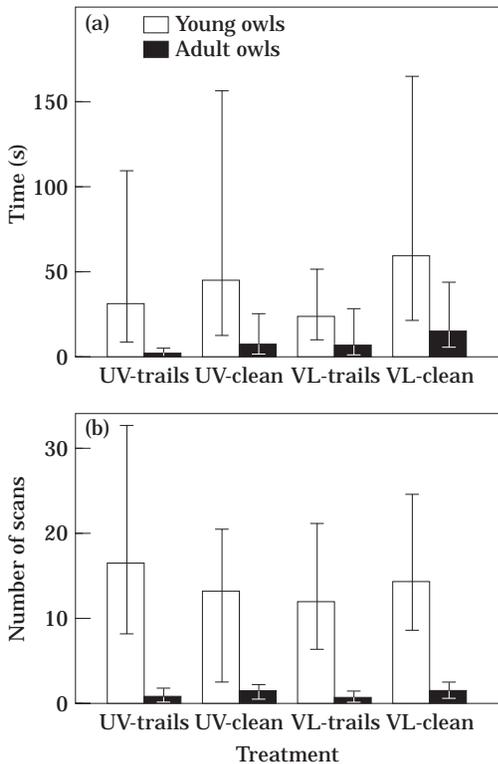


Figure 2. The geometric mean and 95% confidence limits after inverse transformation (Krebs 1989) of 14 young and 14 adult Tengmalm's owls during two 15-min trials (a) in time spent above four arenas and (b) in number of scans to four arenas. The four options were: (1) arena with vole trails in UV light; (2) clean arena in UV light; (3) arena with vole trails in visible light; and (4) clean arena in visible light.

Tengmalm's owls locate prey mainly by acoustic cues (Norberg 1970, 1978; Bye et al. 1992). Male Tengmalm's owls also select particular habitats within their home ranges for hunting. Within each night, they may use a win-stay strategy so that if owls catch prey they return to the same area after delivering the prey to the nest (Sonerud et al. 1986). With these pause-travel and win-stay strategies, UV-vision in particular may be less useful for Tengmalm's owls. However, Tengmalm's owls probably also use vision to detect prey even though they do not rely on visual detection of vole trails. Although the relative amount of UV light is less in the day than at night, the amount of light at night may not allow colour detection. This may apply to UV-vision too.

ACKNOWLEDGMENTS

We thank Harri Hakkarainen and Sten Vikström for assistance in trapping owls, the staff of Konnevesi Research Station for help with the experiments, Heli Siitari-Salmela and Johanna Honkavaara for light measurements and Karen L. Wiebe, Jukka Jokela, Harri Hakkarainen, Esa Lehtikoinen, G. Sonerud and an anonymous referee for valuable comments on the manuscript. This study was funded by the Academy of Finland (to E.K. and J.V.). Tengmalm's owls were captured with the permission of the Finnish Ministry of Environment.

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