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Short Note

Sites with reduced predation risk to young hares within an agricultural landscape

Arnaud Fernex[1], Peter Nagel[1] and Darius Weber[2,*]

[1] Department of Environmental Science, Section of Biogeography, University of Basel, St. Johanns-Vorstadt 10, 4056 Basel, Switzerland

[2] Hintermann & Weber AG, Ecological Consultancy, Planning & Research, 4153 Reinach, Switzerland, e-mail: weber@hintermannweber.ch

*Corresponding author

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During the last 50 years, populations of the brown hare (*Lepus europaeus* Pallas, 1778) have declined throughout Europe (Smith et al. 2005). The reasons are debated (Marboutin and Péroux 1995, Strauss and Pohlmeyer 2001, Smith et al. 2005) and comprise changes in habitats due to agricultural intensification (Smith et al. 2005), mortality caused by mowers, harvesters and other agricultural machines (Strauss and Pohlmeyer 2001), and the impact by predators (Strauss and Pohlmeyer 2001, Reynolds et al. 2009). The land use pattern is linked with the intensity of predation (caused by factors, such as accessibility of prey, range of predatory species or density of predator populations) (Schneider 2001, Panek 2009). Evidence suggests that the observed population decline is the result of low recruitment, because of high leveret mortality (Schneider 1978, Marboutin and Péroux 1995, Strauss and Pohlmeyer 2001). However, the main causal factors linked to this low recruitment pattern are poorly known. An unresolved question is the importance of different land use patterns with regard to their impact on leveret survival. Here, we focus on the predation impact, i.e., which habitat structure favours or hinders the accessibility of leverets for predators. Such information is a valuable input to design management measures for hare conservation. In general, such targeted management of the land use pattern will compensate for adverse predation effects on endangered prey and will be an alternative to predator regulation (Schneider 2001).

Predators prefer to use linear structures, such as paths or field edges to roam the landscape (Phillips et al. 2003, Salek et al. 2009). We hypothesise that it is more probable that predators will find a leveret placed at the edge of a field than hiding in the core area of a field. This is because they forage primarily on rodents and therefore might concentrate their searching activities in sites with high rodent density. In mixed agricultural landscapes of Switzerland, rodent density is highest at the edges and in wildflower strips, whereas the inner parts of crop fields are almost free of rodents in spring, due to agricultural practices (Briner et al. 2005). A second hypothesis is that the vegetation cover of crop fields or wildflower fallows provides better protection than less structured habitats, such as bare fields. We test these hypotheses with lures mimicking leverets, as leverets are hard to find in their habitat and because approaching or even manipulating the leverets or their immediate surrounding area would pose an unnecessary high risk to them.

The study area is situated in north-western Switzerland (47°48′N, 7°58′E). The agricultural area of approximately 5 km^2 consists of 52% arable land and 37% grassland (the remaining 11% consists of special crops such as vineyards, orchards, fallows and others). A spotlight assessment of hare density at the end of winter in early 2010 revealed a low number, with 2.4 animals per km^2 (HOPP HASE Association, personal communication). Potential hare predators in the study area are: Mammals: badger (*Meles meles*), stone marten (*Martes foina*), domestic cat (*Felis silvestris catus*), domestic dog (*Canis lupus familiaris*), pine marten (*Martes martes*), European polecat (*Mustela putorius*), red fox (*Vulpes vulpes*), wild boar (*Sus scrofa*); Birds: black kite (*Milvus migrans*), carrion crow (*Corvus corone*), common buzzard (*Buteo buteo*), common kestrel (*Falco tinnunculus*), common raven (*Corvus corax*), Eurasian eagle owl (*Bubo bubo*), grey heron (*Ardea cinerea*), long-eared owl (*Asio otus*), red kite (*Milvus milvus*), rook (*Corvus frugilegus*), tawny owl (*Strix aluco*), white stork (*Ciconia ciconia*).

The lures had to mimic leverets as much as possible in order to make a potential predator alert, similarly to when predators detect a true leveret. The lures were optimised with regard to size, weight, shape, colour, and weak odour. The bait consisted of specially produced sausages in natural skin, filled with offcuts of meat from a butcher. The meat was neither boiled, salted, spiced or smoked. It was wrapped in brown paper serviettes. The lures were weighed out at about 180 g, which corresponds to a 2-day-old leveret (Stott and Harris 2006). The skin of our lures should guarantee that potential predators were not attracted by the scent of the meat. We tested this aussumption in a preliminary qualitative assessment with a hound. The hound detected the lure normally from a distance of <50 cm, which would be expected with a true leveret. However, the scent of the lures might have intensified as time passed, and therefore we stopped the experiments at the end of the fourth night. We are not able to demonstrate that the odour of our baits was still insufficient to attract foxes or dogs from greater distances during the final night, but we had the impression that the probability of bait detection by mammals did not increase from the first to the last night.

The lures were placed in two positions, one at the edge (bordering other fields but not roads) and one in the centre of ploughed fields, crop fields, hay meadows and wildflower fallows. The minimum distance to the next path, road, forest or building was 30 m. We placed lures only in fields that were at least 10 m wide in order to keep a minimum distance of 5 m between centre and edge. The mean height of the vegetation in crop fields was 63 cm and of wildflower fallows 60 cm. This was almost double the mean height of 33 cm of the hay meadows. The vegetation in ploughed acres had an average height of <5 cm.

From 1 April to 11 June 2010 we placed 16–22 lures per week, covering all four land use types. Each week we selected a different part of the study area. Over the whole period, lures were placed only once in the same field (ploughed fields, crop fields, hay meadows). Because of insufficient numbers, we could not apply the same procedure to wildflower fallows. Therefore, each wildflower fallow was equipped with a second pair of lures after a minimum of 3 weeks and in a different place. The total number of exposed lures during the complete study period was 170.

The use of disposable gloves guaranteed the avoidance of contamination of the lures with human odour. A pair of tongs with a handle 1.5 m in length was used to place the lure in the field, which disrupted the human track at sufficient distance from the bait. The fieldwork was done at night in order to prevent direct observation and, therefore, localization of the lures by possible predators, such as crows. The hay meadows were equipped with lures independently of whether or not they had been mowed.

The exposure period of the lures was 4 nights and 3 days. Camera traps triggered by heat in motion monitored the immediate surroundings of the lures during the survey time (approx. 84 h). We used 18 cameras of the type Capture (Cuddeback, Green Bay, WI, USA), two cameras of the type BolyGuard 5.0 IR (DÖRR, Neu-Ulm, Germany) and two cameras of the type Xtreme 2.0 (Wildview, Grand Prairie, TX, USA).

A lure was categorised as "found by potential predators" when the lure had disappeared after the 3 days, when the lure had been displaced or when a camera trap had recorded the approach of a predator. According to this definition, 98 of the 170 exposed lures were found by a potential predator. Predators found 68% of the lures that were exposed at field edges of all land use types. This figure is significantly higher than the percentage (47%) of detected lures from the centre (χ^2=7.81, df=1, p<0.01). However, in ploughed fields and hay meadows there were no significant differences between the centre and the edge. In contrast, in wildflower fallows (χ^2=7.78, df=1, p<0.01) as well as in crop fields (χ^2=10.1, df=1, p<0.01) potential predators found significantly more lures at the field edges. Predators, especially crows, found 93% of the 42 lures that had been placed in the centre and the edge of ploughed fields. In hay meadows (44 exposed lures) the percentage of detected lures was 55%, in wildflower fallows (42 lures) 45% and in crop fields (42 lures) 38%.

The camera traps recorded carrion crows (*Corvus corone*) as the main predator (44% of the records of identified animals). In sequence of decreasing importance, the following species have been identified from the photographic pictures: domestic cats (*Felis silvestris catus*) (19.7%), domestic dogs (*Canis lupus familiaris*) (18.2%), red foxes (*Vulpes vulpes*) (9.1%), badgers (*Meles meles*) (4.5%), black kites (*Milvus migrans*) (3.0%) and stone marten (*Martes foina*) (1.5%). In 33% of the lures "found by potential predators", the predator could not be identified due to malfunction of camera traps or unclear photographs.

Predators found significantly more lures when exposed at the edges of fields than when exposed in the centre of fields. The results confirm in general the preference of terrestrial predators to roam along linear structures. This pattern is obscured in hay meadows and ploughed fields, most probably because of the low height of the vegetation. Here, terrestrial predators can roam freely in the field with no limitation of sight and the sight of flying birds is also unrestricted. In contrast, the high and dense vegetation of crop fields and wildflower fallows impedes the sight and forms a physical barrier to free roaming. Hence, mammalian predators and birds like carrion crows (*Corvus corone*) prefer to move along existing linear structures, such as edges of fields, with higher vegetation, such as crops or wildflower fallows. The results provide sufficient evidence that predators do not find the lures in all land use types at the same probability. The risk of predation decreases from ploughed fields through hay meadows to wildflower fallows and crop fields.

Leverets run the highest risk of predation during the first 3 weeks after birth (Schneider 1978, Marboutin and Péroux 1995, Strauss and Pohlmeyer 2001). Therefore, we calculated the percentage of lures that would have escaped detection by a predator during 3 weeks of exposure. The results (Table 1) show that only in the centre of crop fields and wildflower fallows would a noticeable proportion of the lures survive 3 weeks of exposure to the predators in our study site.

This study shows that the core parts of crop fields and wildflower fallows are the only relatively predator-safe places for our lures and probably also for leverets in our study area. Crop fields seem to be safe places, which would be an explanation for higher hare densities in arable landscapes compared to grassland landscapes (Holzgang et al. 2005, Smith et al. 2005). The vegetation, however, is often too dense for

Table 1 Estimate of the "survival rate" of the lures at the end of 3 weeks (calculation based on percentage of lures not found after 84 h).

	Survival rate (after 3 weeks)	
	Core area (%)	Field edge (%)
Crop fields	39.7	0.3
Wildflower fallows	19.6	0.1
Hay meadows	0.5	1.6
Ploughed fields	0.0	0.0

hares in crop fields (Rühe 1999, Holzgang et al. 2005). The beneficial role of crop fields on hare densities could possibly be intensified by increasing the seed-row spacing.

Wildflower fallows have been introduced into Swiss agriculture to slow down or prevent the decline of biodiversity in the agricultural landscape (Herzog et al. 2005). They could serve as an important tool for the preservation of viable hare populations. In order to provide this ecosystem service, the mostly narrow wildflower strips should be designed as more compact rectangles in order to reduce the edge effect by a proportional increase of the core area, which is less frequented by predators.

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