A preliminary investigation into whether grazing marsh is an effective refuge for water voles from predation

Jenny L. MacPherson & Paul W. Bright

Royal Holloway University of London, Egham Hill, Egham, GB-Surrey TW20 0EX, United Kingdom, email: jenny.macpherson@rhul.ac.uk

Abstract: The water vole (*Arvicola amphibius*) has suffered a massive and rapid decline in the UK recently, due to habitat fragmentation and predation by American mink (*Neovison vison*). The spatial configuration of the habitat can mitigate the effects of predation on water vole colonies. In reed bed, mink predation rate declines with distance to a main channel. Over-winter mortality of water voles was monitored at an extensive grazing marsh site where mink were present to determine if this habitat provides a similar refuge from predation. Water vole mortality (74% by predation of which 71% by small mustelids) was significantly correlated with channel width and negatively correlated with distance to nearest scrub, suggesting that extensive grazing marsh can provide water vole with some refuge from predation.

Keywords: Arvicola amphibius, *Arvicola terrestris*, American mink, habitat refuge, wetland.

Introduction

The water vole (*Arvicola amphibius*) has suffered a massive and rapid decline in the UK in recent years (Strachan & Jefferies 1993, Jefferies 2003), attributed to the effects of habitat fragmentation and predation by introduced American mink (*Neovison vison*) (Barreto & Macdonald 1998, Barreto et al. 1998). It has been shown that the effects of mink predation on water vole colonies can be mitigated, in some circumstances, by the extent and configuration of habitat (Barreto et al. 1998). In pristine wetland in Belarus, Macdonald et al. (2002) reported that water vole abundance increased significantly with distance from the nearest river bank or lake shore, while the activity of American mink decreased. In the UK, Carter & Bright (2003) found that mink predation in extensive reed beds declined significantly with distance from water channels in excess of 10 m wide. One possible explanation was that mink and other terrestrial small mustelids are less active within reed beds and consequently less likely to encounter water voles there. Extensive grazing marsh with networks of ditches and channels of varying widths is another type of habitat that could potentially provide a partial refuge for water voles from predation by American mink. Habitat refuges offer a potentially sustainable, long term solution to water vole conservation and, by supporting source populations (Pulliam 1988), are likely to enhance the viability of water vole metapopulations in surrounding landscapes.

The objectives of the present study were to investigate over winter mortality of water voles at an extensive grazing marsh site where American mink were present, and to consider if any characteristics of this type of habitat reduce the level of mink predation on water voles.

Methods

The study was carried out at West Sedgemoor, Somerset, England (Ordnance Survey grid reference ST 361 238), a 584 hectare grazing marsh owned and managed by the Royal Society for the Protection of Birds.

Between October and November 2005 water voles were captured in live traps and capture locations recorded using a handheld GPS (Garmin Ltd., Romsey, Hampshire, UK) with a maximum error of ten meters. All animals heavier than 150 g were fitted with a radio collar (Biotrack, Dorset, UK) with a temperature-dependent mortality switch, which transmits an altered signal when an animal dies.

Radio collared water voles were located at twice weekly intervals from the commencement of trapping until February 2006 using hand-held Yagi antennae and Telonics radio receivers (Telonics, Mesa, Arizona, USA). Dead voles were retrieved and cause of mortality determined from a combination of field signs: tooth marks on collar and/or the corpse (Lyver 2000); predator hairs, scats or tracks in the immediate vicinity (Lawrence & Brown 1973); condition and location of the corpse. Predation was assigned to a small mustelid if the corpse was located within a water vole burrow which would be inaccessible to an avian or larger mammalian predator. Predation was only assigned to mink if there were mink scats or odour near a corpse, or canine punctures 9-11 mm apart on a water vole skull (Dunstone 1993).

To assess American mink activity at the site, mink rafts were placed approximately 1 km apart along main water courses within the reserve (Reynolds et al. 2004) and these were checked weekly. A systematic search was also carried out along smaller watercourses, tracks and linear features and all signs of mink activity were recorded.

Generalised linear models (McCullagh & Nelder 1983) were used to examine potential correlates of water vole survival. Explanatory variables considered were: site, distance from tree cover, distance from nearest scrub line, distance from 10 m channel, and width of channel along which each water vole's centre of activity was located. The binary response variable, whether an animal was predated or not, was offset by the number of weeks each vole was radio collared, since collars were not all first attached in the same week.

Results

A total of 39 animals were radio collared, of which 15 were captured less than 80 m from the main (>10 m wide) drainage channel, and the remainder were captured along small (≤5 m wide) ditches within the grazing marsh (table 1). Two animals absented within five days of being collared, so may have dispersed and were therefore removed from the dataset.

Predation accounted for nearly 74% of mortality; with confirmed small mustelid kills accounting for 71% of predation (table 2). Nine animals went missing after being monitored for several weeks, during which they remained at, or near, their original site of capture. It is unlikely that these adult voles would have dispersed out of radio receiver range (see Moorhouse et al. 2009) so it is most probable that they were also predated, but collars and any remains were not recovered. Following the protocol of Carter and Bright (2003), mortality was not assigned to American mink predation unless there was unequivocal evidence. In most cases in the present study the skull was absent or only partial remains were found, and scats were never found in the immediate vicinity, so there were no indisputable cases of mink predation. However the small mustelid category almost certainly includes at least some unverified mink kills. Signs of American mink were found at one of the mink rafts along the main channel and by a scrub line along a drove (track) nearby.

There was a significant difference in the minimum number of weeks alive between animals living less than 1500 m from a 10 m wide channel (9 ± 1.6) and those whose burrows were more than 1500 m from a 10 m wide channel (16 ± 1.5) (Mann-Whitney U test: Z=-2.205, n_1=15, n_2=22, P=0.027). In a generalised linear model, although the total deviance explained was relatively low,

Table 1. Width of channel and distances to main channel and scrub for each radio-tracked animal's home burrow/ centre of activity.

Animal	Channel width (m) on which home burrow located	Distance (m) to nearest 10 m wide channel	Distance (m) to nearest scrub
1	5.0	69.9	133
2	5.4	68.4	17.5
3	5.5	76.3	378
4	5.2	68.8	70
5	5.4	73.2	293
6	5.1	72.2	265
7	5.1	69.5	98
8	5.1	68.6	22.5
9	5.4	72.0	265
10	5.4	76.7	378
12	5.0	72.4	249
13	2.7	78.9	451
15	2.4	68.2	332
16	2.4	1700	383
17	2.4	1720	348
18	2.4	1630	434
19	2.4	1630	434
20	5.0	1320	742
21	2.4	1630	432
22	2.4	1640	396
23	2.4	1700	383
24	3.2	1570	485
25	5.0	1570	485
26	3.3	1600	442
27	2.4	1800	257
28	1.6	2300	126
29	1.6	2200	124
30	1.4	2200	117
31	1.3	2000	129
32	1.8	2100	84
33	5.0	1560	425
34	4.2	1630	425
35	4.2	1640	434
36	1.8	2200	117
37	3.2	1590	465
38	4.1	1390	662
39	1.4	1480	317

water vole mortality from predation was significantly correlated with channel width and negatively correlated with distance to nearest scrub (table 3). There were no significant interactions between either of the explanatory variables.

The predicted probability of mortality from predation for water voles in the present study

Table 2. Summary of water vole survival at West Sedgemoor (near = burrow <1500 m from main channel; far = burrow ≥1500 m from main channel).

	Near	Far	Total
Surviving	2	7	9
Predated *)	4 (4)	10 (6)	14 (10)
Other mortality	2	3	5
Missing	7	2	9
Total	15	22	37

*) in brackets: by small mustelids

increases as the width of channel on which their burrow/centre of activity is located increases (figure 1).

Discussion

The results of the present study suggest that some features of extensive grazing marsh have the potential to provide water voles with, at least a partial refuge from predation. There are a number of potential mechanisms for this effect. Spatial refugia can be areas which are not used at all by a particular predator because the habitat physically excludes or deters them (Gause et al. 1936, Atsatt & Odowd 1976). It is unlikely that this is the case for mink along small ditches in grazing marsh. In reed bed habitat, American mink are constrained to easily navigable channels (MacPherson 2010), probably because the interstitial habitat is energetically costly to move through. The terrestrial gait of American mink has been described as "scampering" (Dunstone 1993), and this is difficult to do amongst dense reed. The most efficient way for mink to traverse this type of habitat is by swimming underwater, as this has been estimated to be up to ten times less energy demanding than surface swimming (Williams 1983). This is only achievable in wider, deeper channels.In grazing marsh the flat, open terrain between channels and ditches is more easily navigable, however American mink show a strong avoidance of open areas (Gerell 1970, Dunstone 1993, Previtali et al. 1998, Yamaguchi et al. 2003) where they may be vulnerable to predation by foxes and dogs (Bonesi & Macdonald 2004). Mink escape by diving when attacked by predators and usually rest near deep water so as to have access to an escape route (Zabala et al. 2007b). Narrower ditches and channels may not provide sufficient depth of water for this to be effective. Habitat features that increases the risk to the predator, reducing the predator's activity, may provide prey with a spatial refuge (Brandt & Lambin 2007).

American mink foraging is usually restricted to the vicinity of den and suitable resting sites (Birks & Linn 1982). Therefore the distribution and availability of such sites is likely to be a significant factor in determining if and where mink forage in grazing marsh. This should be considered when assessing potential refuges for water voles in this type of habitat. It has been suggested that American mink use a small range of structures that allow for efficient foraging and ranging, and that lack or removal of these structures could render areas of abundant food effectively useless to mink (Zabala et al. 2007b).

Mink hunting behaviour is characterised by a fairly rigid suite of behaviours (Dunstone 1993). The most common is a detailed search-stalking behaviour in bramble thickets or areas of rank undergrowth. In more open areas American mink have been observed to move quickly along riverbanks stopping occasionally with raised heads to detect prey (Zuberogoitia et al. 2006). Dive rates are highly variable between individual mink (Hays et al. 2007) and diving as a hunting technique is thought to be related to high availability of a particular prey (Zuberogoitia et al. 2006). However it is unlikely that mink will hunt by pursuing its prey in vegetated waters with poor visibility and where mink cannot be fast enough. On smaller, undisturbed channels, submerged and emergent vegetation will provide water voles with refuges from predators (Barreto et al. 1998). It may also be the case that the observed refuge effect of narrow

Table 3. Generalised linear model examining water vole mortality from predation (n=37, of which $n_{predated}$=14) at West Sedgemoor (response variables in GENSTAT: binomial errors, logit link) offset by the number of weeks each animal was radio collared. Parameter estimates and s.e.s are in logits.

Explanatory variable	Parameter estimate	s.e.	Deviance	χ^2 probability
Constant	-26.236	0.418		
Nearest scrub	-0.00509	0.00108	12.35	<0.001
Channel width	2.007	0.111	16.24	<0.001
			Total deviance explained:	27.3%

ditches and channels results from the likelihood that they will be visited less frequently by mink, as they support a lower abundance and variety of prey species (Dunstone 1993).

Whilst there were no indisputable cases of American mink predation, more than 70% of predation on water voles during the course of the study was unequivocally attributable to small mustelid, which could include Western polecat (*Mustela putorius*), American mink, stoat (*Mustela erminea*) and weasel (*Mustela nivalis*). Polecats are not present but there was evidence of mink, weasel and stoat at the site.

Small mustelids, including American mink, frequently forage along linear features, and mature trees have been shown to be important as den sites for American mink (Halliwell & Macdonald 1996). This is why distance from track and nearest tree were also considered as potential explanatory variables. However, removal of these from the model did not significantly reduce the amount of deviance explained.

A limitation of using field signs to detect mink presence is that they provide no information on the age or sex of the animal(s). On a river system, Zabala et al. (2007a) found that female American mink preferred smaller streams than males, although the home range of females still included sections of the main (>10 m wide) river, usually at its junction with the tributary. It has also been shown that, in warm seasons, mink sometimes occupy marsh habitat some distance from stream banks (Sidorovich et al. 2001), so it may be that the partial refuge effect, observed here over winter, is seasonal. Further study is required to determine if this is the case.

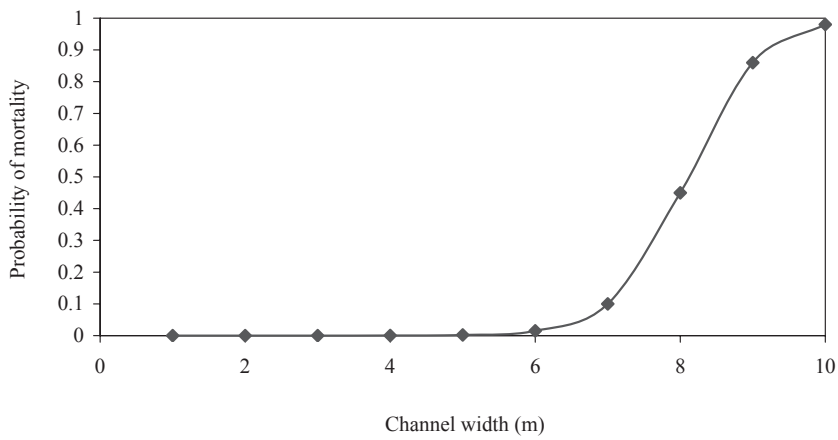

Figure 1. Predicted risk of water vole mortality from predation in relation to the width of channel on which a home burrow/centre of activity is located. Line represents the fitted relationship from a generalized linear model.

Conclusion

In conclusion, the rate of predation on water vole in the present study was observed to be lower on narrower ditches in grazing marsh than along the wide main channel. It is recommended that further research should be conducted to determine if this is the case throughout the year and at other similar sites, both with and without mink.

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Samenvatting

Een voorlopig onderzoek naar de betekenis van begraasd moerasland als effectief toevluchtsoord voor de woelrat tegen predatie

De woelrat (*Arvicola amphibius*) is recentelijk in het Verenigd Koninkrijk sterk en snel achteruitgegaan, met name door versnippering van het leefgebied en predatie door de Amerikaanse nerts (*Neovison vison*). De ruimtelijke structuur van het leefgebied zou deze predatie mogelijk kunnen verminderen. In rietlanden neemt de predatie af naarmate de afstand tot de hoofdwatering toeneemt. Om na te gaan of (extensieve) begrazing van rietland, waar naast de woelrat onder meer ook de Amerikaanse nerts voorkomt, een geschikte maatregel is om eerstgenoemde soort te beschermen, werd de mortaliteit van de woelrat gedurende de winter in zo'n begraasd gebied vastgesteld. Het blijkt dat de mortaliteit (74% door predatie en van deze predatie 71% door kleine marterachtigen) positief significant gecorreleerd is met de breedte van de meest nabije waterloop en negatief met de afstand tot het dichtstbijzijnde struikgewas. Dit suggereert dat begrazing van rietland metterdaad voor de woelrat enig soelaas kan bieden tegen predatie.

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