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ABSTRACT

Aerial nest surveys are the principal method of monitoring the distribution and habitat preferences of harvest mice (*Micromys minutus*), but monitoring has rarely been undertaken for more than three years at any site. Although nest surveys have inherent errors, they remain the most easily accessible and cheapest method. The aim of this study was to count the number of nests found in consecutive years at two sites in southern England. We found that the harvest mouse nest densities fluctuated over time. This supports other studies that indicate harvest mice populations undergo major fluctuations from year to year. Although the drivers of this annual variation in nest numbers have not yet been identified, surveying for harvest mice using aerial nest counts in just one year could underestimate their likely presence at that site.

INTRODUCTION

The harvest mouse (*Micromys minutus*) is Britain's smallest rodent, with adults weighing 5-7 g on average and pregnant females up to 15 g (Trout 1976). In the wild they have a short lifespan, usually six to eight months with many individuals surviving only one winter (Trout 1976). It is the only British rodent to build above-ground nests for breeding and shelter, providing a characteristic field sign to determine their presence in a habitat. The nest disintegrates before the following breeding season (Trout 1978). Thus, indirect data can be obtained on harvest mouse distributions by locating these nests (Trout 1976) and counting the number of nests in a defined area usually in the autumn and winter. The habitat characteristics of the nest can also be recorded (Bence *et al*. 2003). Tall dense vegetation, including grass, reedbeds, rushes, grassy hedgerows, bramble patches, and cereal crops are favoured for breeding nest construction with shelter nests usually built lower down in the vegetation (Trout 1976; Harris 1979).

Harvest mice have been known to undergo marked changes in density on a seasonal and annual basis (Trout 1978), but most studies have collected data for less than three years and many employ live trapping rather than locating nests on the same site over successive years. Seasonally dependent live trapping using ground and aerial traps is currently the best method to study harvest mice directly (Kettel *et al*. 2016; Darinot 2019). However, this method is labour intensive, costly, requires training and incurs ethical considerations relating to live capture. Harvest mice are an understudied species, suggesting a suite of study methods should be utilised where possible to contribute to the scarce body of knowledge. We provide data on harvest mouse nest densities over consecutive years at two sites in southern England enabling nest abundance changes to be investigated.

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STUDY SITES AND SURVEY METHODS

The two study sites were Sheerland Farm, Kent (TQ 933 454), a commercial fruit farm with orchards and two cereal fields located on the south-facing Wealden Greensand Ridge, and Chimney Meadows National Nature Reserve, Oxfordshire (SP 354 013), a farm owned by the Wildlife Trust lying on the Thames floodplain. At one time Chimney Meadows was a commercial farm cultivating wheat and barley but in 2003 it was converted to livestock grazing and species-rich wildflower meadows.

Sheerland Farm

One field margin (approximately 1 ha), a reservoir margin (which was created six years before the first survey was undertaken and approximately 0.5 ha) and an area of set-aside (approximately 2.7 ha) totalling 4.2 ha (Figure 1a) were searched in every autumn and winter between 2004 and 2016 except 2011. The field margin comprised couch grass (*Elymus repens*) and cocksfoot (*Dactylis glomerata*), with bramble (*Rubus fruticosus*, agg.) dominant in places, while the reservoir margin consisted of pendulous sedge (*Carex pendula*), compact, soft and hard rushes (*Juncus conglomeratus, J.effusus and J.inflexus*), water plantain (*Alisma plantago-aquatica*), greater reedmace (*Typha latifolia*) and bramble. The set-aside at various times was composed of kale (*Brassica oleracea*) mixed with quinoa (*Chenopodium quinoa*), turnip (*Brassica rapa* subsp. *rapa*), lacy phacelia (*Phacelia tanacetifolia*), bristly ox-tongue (*Picris echioides*), great hairy willowherb (*Epilobium hirsutum*) and various grass species. Targeted autumn-winter visits were carried out solely by SK.

Chimney Meadows

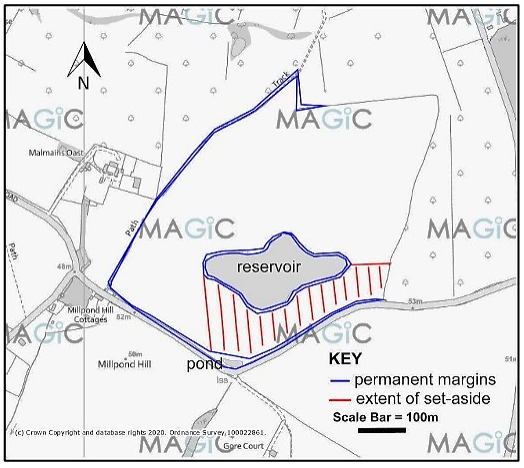
Two field margins (approximately 0.84 ha and 1.32 ha, Figure 1b) totalling 2.16 ha were searched between 2014 and 2020 by members of Oxfordshire Mammal Group and Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust (BBOWT). The number of volunteers for each year at Chimney Meadows were: 20 (2014 & 2015), 18 (2016 & 2017), 11 (2018) and five (2020). Both margins were searched every year from 2014 to 2020, except in 2016 when margin B was not surveyed and in 2019 when neither margin was surveyed.

Margin A's vegetation comprised reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), thistle (*Asteraceae* family), nettle (*Urtica dioica*), broad-leaved dock (*Rumex obtusifolius*), tufted hair grass (*Deschampsia cespitosa*), false oat grass (*Arrhenatherum elatius*), rushes (*Juncus* species) and sedge species (*Carex* species). Margin B was dominated more by tufted hair grass, sedge species and common reed with lower frequencies of ruderals such as nettle and dock. All suspect nests were determined as harvest mouse or otherwise by AJL.

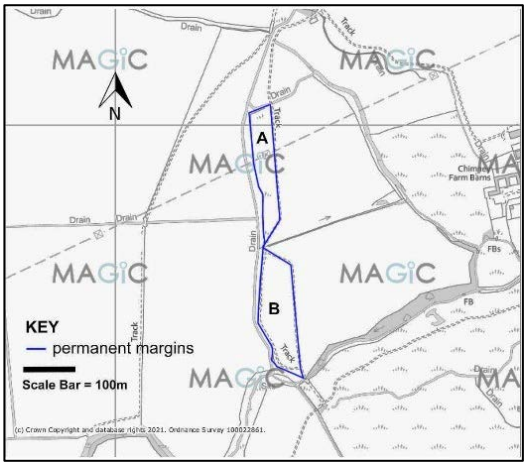
The number of nests found on each margin were converted to a density (no/ha) using the area of the margin. High, moderate and low density years were determined by calculating the upper and lower quartiles of the yearly nest density in each margin at each site. Nest densities above the upper quartile were classed as high, densities between the upper and lower quartile range were moderate, and nest densities below the lower quartile were classed as low.

Figure 1: Maps of study sites (a) Sheerland Farm, (b) Chimney Farm. Survey areas highlighted in blue and red.

(a)



(b)



RESULTS

The upper and lower quartiles and other descriptive statistics for nest densities (no./ha) for each site are shown in Table 1. On the three margins at Sheerland Farm nest densities showed little consistency over time, with high densities on the field margin in 2004, 2007 and 2009, moderate densities in 2005-2006, 2008, 2012, 2014-2015, and low densities in 2010, 2013 and 2016 (Figure 2a). The reservoir margin had high densities in 2004, 2007 and 2014, moderate densities in 2005-2006, 2009, 2012-2013 and 2015, all other years being low. A small number of nests were found in the set-aside in 2004 and 2007 but not at other times. At Chimney Meadows, margin A, which was not searched in 2019, had high nest densities in 2014 and 2016 with a moderate density in 2017-2018 and low densities in other years (Figure 2b). Margin B was not searched in 2016 or 2019 and had a high density in 2014 and 2018 with a moderate density in 2017. This margin had low densities in all other years.

No nests were found at Sheerland Farm on the field margin and reservoir in 2010 and 2016. All years except 2004 and 2007 had zero nest counts on the set-aside. At Chimney Meadows no nests were found in 2015 on margin B.

Table 1: Descriptive statistics for nest densities (no./ha) at each site. N = number of surveys

Site	Survey Area	N	Mean	Median	Upper quartile	Lower quartile	Max.	Min.
Sheerland Farm	Field margin	12	49.7	11.0	83.0	3.5	198.0	0.0
	Reservoir	12	19.5	4.5	15.3	2.5	91.0	0.0
	Set-aside	12	0.3	0.0	0.0	0.0	1.9	0.0
Chimney Meadows	Margin A	6	36.7	24.4	63.1	17.0	73.8	7.1
	Margin B	5	8.3	6.1	9.1	2.3	24.2	0.0

DISCUSSION

According to the nest densities we found, there were high density years in 2004, 2007, 2009, 2014, 2016 and 2018. Although our sites only overlapped in time between 2014 and 2016, they both show a high year in 2014 with a subsequent low in 2015. Uncontrollable external events occurred on each margin at both farms which may account for the fluctuations rather than inherent population cycling as seen, for example, in voles and lemmings (Selås 2006 and references therein). The feeding of domestic ducks which were introduced to Sheerland Farm in the autumn of 2006 was probably responsible for an increase in rat populations around the reservoir and southern margin (SK, *pers.obs*). Rats predate on other small mammals (Shepherd & Ditgen 2012), potentially impacting on harvest mice. Nest densities at the reservoir margin did reduce slightly, (78 nests/ha in 2005 to 58 /ha in 2006) but increased by a corresponding amount on the southern margin and overall remained at levels similar to the previous year. After the ducks were moved away in spring 2007, there was less supplemental feeding, and the rats were controlled. Thereafter the nest numbers increased (35.24 /ha, 2007) with a decrease (0.71 /ha) in 2008. As the willow increased in size and extent, sedge viability around the reservoir reduced, potentially impacting the population by removing suitable nest-bearing plants (e.g. grasses and sedges). This is reflected in nest densities around the reservoir, although nest densities found within the field margin also fluctuated. The set-aside was replanted every spring with short and fragile grasses which were mostly unsuitable for nesting harvest mice. However, in the high years of 2004 and 2007, small numbers of nests were found where grasses and support permitted (1.85 /ha in both years).

A new fence was installed on both margins at Chimney Meadows (A in May 2015 and July 2015 for B) removing habitat connectivity and this may have affected the harvest mouse population which dropped from 73.40 /ha in 2014 to 7.14 /ha in 2015 on margin A. As the vegetation recovered, nest numbers increased to 73.81/ha in 2016. Margin B also showed a decline in nest densities between 2014 and 2015, but no survey was undertaken in 2016. Grazing of margins prior to 2016 could have destroyed nests prior to the autumn survey and reduced plant vegetation cover between 2014 and 2016; but high densities found in 2014 does not support grazing by livestock as causing the nest count fluctuations. Both margins were flooded in October 2019 remaining under water until March 2020 (Louise King, *pers.comm*), with water levels fluctuating during this time. However, nests were found the following year albeit at low densities.

Although the number of participating volunteer novice surveyors at Chimney Meadows did not change markedly over the survey, it is possible that fluctuations in nest numbers reflect the group of volunteers used each year and their ability to find nests. A single surveyor (SK) undertook the Sheerland Farm surveys so numbers of surveyors or their nest finding abilities had no influence on the fluctuations in nest densities found.

A literature review found very few published works on nest surveys longer than one year. Most nest studies focussed on nest size parameters, the placement of nests within habitats or the presence of nests found during live capture studies (Bence *et al*. 2003; Surmacki *et al*. 2005; Riordan *et al*. 2009; Čanády 2013; Kettel *et al*. 2016; Darinot 2019). Hata (2011) carried out a study on three sites over five years (1999-2005) and reported the total number of nests per site (1,505, 543, 176) rather than nests per site per year. Sleptsov (1947 *in* Trout 1978) counted nests in eight habitat types over four consecutive years between 1941-1944. Nest densities varied considerably between habitats and between years from a low of 71/ha in *Calamagrostis* reed grass in 1944 to a high of 398/ha in a rice field in 1941. In fact, highest nest densities were found in all habitats in 1941 and lowest in 1942 suggesting some synchrony in harvest mouse numbers across different habitats. Geographical location, habitat and changes in land management since the 1940s may have led to a decline in harvest mouse populations in Britain (Matthews & Harrower 2020).

CONCLUSION AND RECOMMENDATIONS

It is likely that not all nests were found, but we are confident that by using a consistent survey effort at each site representative samples were obtained indicating wide annual fluctuations, as reported in other studies (Trout 1978). Further studies are needed on what causes these year-to-year fluctuations. Zero nest counts in one or more years can happen but if the species persists in the wider landscape then recolonisation can occur if habitats are connected. We therefore recommend long term monitoring of populations, using nest surveys at several sites within an area to understand the temporal and spatial dynamics of harvest mice.

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