The Mammal Society Research Report No. 2

The National Yellow-Necked Mouse Survey

Aidan Marsh

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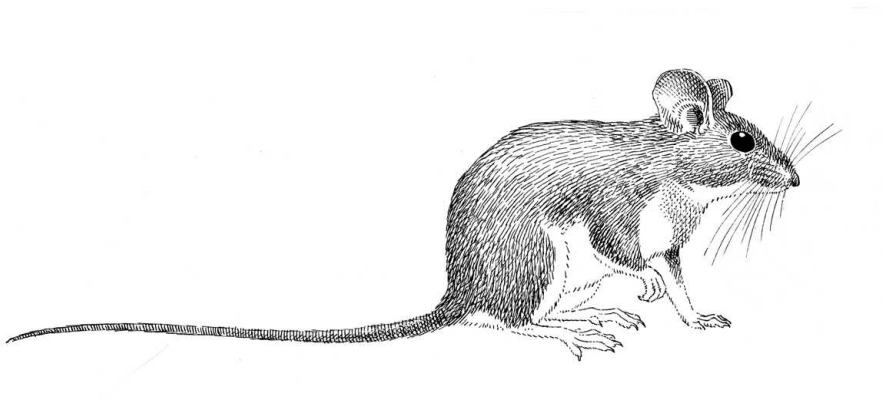

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2B Inworth Street
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Survey Objectives

1. To collect and review all available data on the distribution of the yellow-necked mouse in Britain.

2. To establish a network of experienced small mammal trapping volunteers to conduct extensive woodland surveying for an exploratory study.

3. To establish a workable woodland small mammal survey technique by which the relative abundance of populations could be measured quickly and simply.

4. To select, measure and evaluate specific woodland habitat and landscape variables that may affect the relative abundance of yellow-necked mice.

5. To assess the current status of the yellow-necked mouse in Britain and reassess perceptions in order to stimulate focused future research.

6. To compare and evaluate the updated distribution map for the yellow-necked mouse with climatic data and other factors that may influence the national range of this species.

7. To use these data to suggest any appropriate woodland management practices that may benefit the conservation of the yellow-necked mouse.

Points (2)–(5) will be addressed in this report. These relate specifically to the results from the live trapping survey conducted in the latter part of 1998.

Points (1), (6) & (7), including data from the "A Mouse in Your House?" questionnaire, will be addressed in the next phase of the analysis.

A full and final analysis of *all* the above objectives will be published in *Mammal Review* in due course.

Executive Summary

The yellow-necked mouse was found to be widespread within suitable woodland inside its natural range (occupying 71% of these sites).

The survey results lend support to the broad outline of the current distribution map. However, they do suggest minor additions to its range as well as highlighting the absence of records from Cornwall and Cheshire, despite extensive surveying.

Where found alongside the wood mouse, the yellow-necked mouse was the more abundant rodent on 15% of occasions, far more often than previously thought. However, there may be considerable inter-annual variation and this study provides only a snap shot of the situation.

Yellow-necked mice were found in woodland of all ages but were more abundant in woods of ancient origin, confirming that such woods may offer the best habitat for this species.

Woodland size was not an important factor. However, the degree of isolation from large neighbouring woods was important. Isolation distances over 2000m lead to a decreased chance of finding yellow-necked mice.

There was some evidence to show that the presence of yellow-necked mice correlates with a reduction in the proportion of breeding male wood mice. This suggests the possibility of interspecific male-male interactions.

The presence of yellow-necked mice at a site did not have any apparent affect on the relative abundance of either wood mice or bank voles.

Using a logistic regression model based on management level and the ivy cover on trees, 73% of woods could be correctly classified as present or absent for yellow-necked-mice.

Contrary to expectations, woods with higher levels of management were associated with the presence of this species, as were woods with less tree ivy cover. Tree ivy coverage is climate regulated and this may have a bearing on the result.

General Introduction

The distribution and status of the yellow-necked mouse in Britain

The yellow-necked mouse (*Apodemus flavicollis*) is a close relative of the wood mouse (*Apodemus sylvaticus*), one of the most common and widespread species in Britain. While the wood mouse has been recorded in almost every corner of these islands, the yellow-necked mouse has a noticeably restricted range. Recent distribution maps suggest that this species if found predominantly in the south-east, south and west of England and in central and eastern Wales: it is noticeably absent from the southern Midlands, around Oxford and from the north and far south-west[1].

Reasons for this unusual distribution have remained something of a mystery, as has the status of this species. The yellow-necked mouse is seldom seen and relatively little recording is carried out for small mammals. As a result the status of this species is often the subject of speculation. Several authors have suggested that the numbers and/or range of the yellow-necked mouse may have declined and that monitoring and research is needed to evaluate the current status of this species[2,3,4]. This project was designed to test potential monitoring techniques.

The history of the yellow-necked mouse in Britain

The yellow-necked mouse is native to Britain, having probably become established in Mesolithic or early Neolithic times. At this time, it may have been the common woodland mouse, possibly excluding the wood mouse from this habitat[5]. Certainly, in these former times the range of the yellow-necked mouse appears to have been slightly wider, as suggested by archaeological remains from Dowel cave, Derbyshire, Roman Manchester[6] and elsewhere[5]. Records from the late nineteenth and twentieth centuries also indicate that the current distribution of the yellow-necked mouse may be more restricted than it was in quite recent times.

The yellow-necked mouse in Europe

In much of Europe the yellow-necked mouse is one of the commonest woodland rodents. Unlike the situation in Britain, it is often numerically dominant where it occurs alongside the wood mouse or the striped field mouse (*Apodemus agrarius*). Despite the extensive research conducted on the yellow-necked mouse in Poland[7,8,9], Sweden[10,11,12,13], Germany[14], Italy[16] and Spain[17,18] care must be taken when attempting to extrapolate results in Britain. The differences in rodent fauna, habitat and rural landscapes between the British Isles and continental Europe mean that European research is no substitute for research into British populations. A species at the edge of its geographical range is often subject to different ecological and evolutionary pressures.

The comparative ecology of the yellow-necked mouse and wood mouse

Localised studies suggest that the yellow-necked mouse tends to be associated with mature deciduous woodland[19,20,21] and with woodland areas displaying a wide diversity of seed bearing tree species[22]. A good correlation exists between the current distribution of deciduous woodland and yellow-necked mice[23]. Rackham's[24] historical study highlighted the southerly distribution of Domesday woodland and 19th century coppice, which also closely correlates with the present range of the yellow-necked mouse[23]. As a result, this species has been described as an ancient woodland species, in much the same way as the dormouse[25], although the evidence to support this is weak. In coppiced woodland the yellow-necked mouse is the only rodent to prefer older, more established compartments and it is seldom recorded in recent coppice[26,16]. There is still very little research into the effects of different woodland management practices on yellow-necked mouse populations.

As well as the woodland habitat itself, the surrounding landscape, including land use, distances to neighbouring woodlands, and connectivity between woodlands, may also affect *Apodemus* [27,28,29,30]. The yellow-necked mouse can be vulnerable to habitat fragmentation[31] and its perceived habitat specificity may contribute to this[32]. However, there is very little evidence on which to judge the degree of woodland isolation that might

affect yellow-necked mouse populations. Both species of *Apodemus* are known to be able to travel over 1000 m in short periods [20,33,34].

It is argued that some form of niche separation must occur between yellow-necked mice and wood mice in order to avoid direct competition and allow these two species to live in the same woods.. One common suggestion is that yellow-necked mice may spend more time arboreally than wood mice[35,36].. Both species of *Apodemus* are proficient climbers[37] and both species are commonly recorded in tree based nest boxes[38,39,40]. A yellow-necked mouse has been recorded in the canopy in Poland at a height of 23m[41].

Methods

Survey participants

Methods Summary

- Survey period between 1 September and 30 November 1998.
- Deciduous woodland sites >2ha selected by experienced volunteers.
- 40 Longworth traps used for two nights in each wood to give relative abundance index.
- Woodland size, age, national vegetation class and isolation were assessed, as well as seven internal habitat variables.
- All rodents identified were sexed, weighed and breeding condition assessed.

It was important that volunteers could reliably identify small mammals and assess other straightforward physical determinants of rodent gender and reproductive condition. To achieve this, survey volunteers were largely drawn from members of The Mammal Society, wildlife professionals, and experienced naturalists. A few volunteers without the necessary skills were directed to experienced people willing to help with training and access to the literature, as appropriate.

Site selection and survey timing

The survey period was from 1 September 1998 to 30 November 1998, a 3-month window chosen to coincide with the period of peak small mammal abundance. Two surveys conducted just outside these dates were also included. Surveyors were asked to select their own survey sites, providing they chose predominantly deciduous woodland >2ha in size. Very small woodlots, coniferous woodland and other types of habitat were excluded as these were considered, *a priori*, to be marginal habitats and therefore of lesser importance than deciduous woodland. Sites were not pre-selected for volunteers as this would have reduced involvement, sample size and geographical coverage. In total, around 350 volunteers were involved, often working in pairs or groups.

Longworth trapping protocol

All surveyors used 40 Longworth live-capture traps for the survey, which was carried out over two consecutive nights. Two trap lines were laid in each woodland, each one consisting of ten pairs of traps placed at approximately 15m intervals. Transect lines were laid at least 50m from the edge of the woodland and at least 100m from each other. Each trap location consisted of two traps laid within 1m of each other in promising capture positions. Hay was provided as bedding in traps and food in the form of rolled oats (or similar) was provided. All traps also contained blowfly pupae or an alternative source of meat for shrews in order to minimise trap deaths amongst these active insectivores.

Traps were laid down on the afternoon of day 1 and checked as early as possible on the morning of day 2. They were then reset and checked on the morning of day 3 before being removed. All animals caught were identified, weighed, sexed, and their reproductive condition assessed. In order to minimise any distress to shrews that were caught they were usually identified to species and then released. Animals captured on day 2 were fur clipped to identify them as recaptures if caught again on day 3.

One subtle variation in methodology should be noted. In woodland, trap mortalities *without* an evening trap round are usually very low where care is taken to provide sufficient food and bedding and adverse weather conditions are

avoided. This was borne out in the results of this study. However, as the welfare of the animals was paramount, an evening trap round on day 2 was an accepted deviation from the main protocol, provided certain procedures were followed. Where traps were checked on the night of day 2, animals caught were recorded as day 3 captures (or recaptures) as they would still have been there the following morning. The traps from which they came were left closed overnight to avoid increasing the overall trap effort used. The implications of the methodological variation are addressed in the discussion.

Landscape and habitat variables: selection and scoring

Seven habitat variables and three main landscape variables were assessed for each woodland site (see Table 1). Habitat variables were assessed at every other trap point in an area of 3m radius around the traps and then averaged to give an overall score.

In addition data was collected on planting dates, National Vegetation Classification (NVC) class[42] and age category. Planting dates were usually obtained from landowners records, although this was not always possible. The age category of each woodland was assessed as either Recent Woodland (RW), Ancient Replanted Woodland (ARW) or Ancient Semi-Natural Woodland (ASNW). ASNW is woodland planted pre-1600, ARW is woodland originally planted pre-1600 but replanted since and RW is woodland planted post-1600.

Data handling and analysis

All data were initially entered into an *Access* database and subsequently imported into *SPSS* for Windows for the analysis.

The variables of woodland area (ha), distance to the nearest small woodland (>2ha) and distance to the nearest large woodland (>20ha) were all recalculated and standardised using Pathfinder 1:25,000 OS Maps. Initial checks revealed a considerable variation in the accuracy of these somewhat subjective measurements by surveyors.

For every rodent capture and every site there were a number of pieces of information to record and missing data were relatively common. Dichotomous coding variables were created to allow unreliable data to be excluded from relevant parts of the analysis. For example, animals sometimes escaped before they were processed. Where two or more escapes occurred on the first trap round, before the animals were fur clipped, the "escapes" variable was marked appropriately. As such escapes could alter the abundance index calculated, the coding variable allowed this site to be excluded from relevant parts of the analysis.

The categorising of rodents as adults, sub-adults and juveniles is difficult and subjective.

Table 1. Variables measured for each woodland site.

Abbreviation	Variable Description	Data Type
Woodland descriptives		
NVC	NVC woodland classification	Categorical (1-5)*
PLANTING	Woodland planting date	Categorical (1-5)
AGE	Woodland age category (RW, ARW, ASNW)	Categorical (1-3)
Landscape variables		
AREA	Woodland area (ha)	Continuous
ISO2	Distance to nearest woodland >2 ha	Categorical (1-5)
ISO20	Distance to nearest woodland >20 ha	Categorical (1-5)
Habitat variables		
CANOPY	Canopy cover	Categorical (1-5)
HERB	Herb layer cover	Categorical (1-5)
HUMAN	Human impact level	Categorical (1-5)
LOGS	Fallen timber on ground	Categorical (1-5)
MANAGE	Management level	Categorical (1-5)
LIANAS	Free-hanging climbers in trees	Categorical (1-5)
IVY	Ivy coverage on trees	Categorical (1-5)

*Categorical data is information assigned to one of several categories rather than measured on a continuous scale

Records of animal age class were carefully examined and there was no true difference between the sub-adults and juveniles age classes. Therefore, these two categories were merged into one pre-adult class. In the categorisation of adults and pre-adults there still appeared to be a small percentage of inaccurate age classifications, and to control for this a reclassification of outliers was implemented based on weight. All animals that were over 2 standard deviations outside the mean weight for their selected age class were reclassified. Although this procedure could be iterative, reclassifications were only made once. This lead to the reclassification of 39 (1.5%) wood mice, 7 (1.6%) yellow-necked mice and 8 (1.6%) bank voles into new age classes.

All continuous variables were checked for normality and homogeneity of variance. Wood mice were the only species whose relative abundance was normally distributed on transformation [Log (x +1)]. Yellow-necked mouse and bank vole abundances were not normally distributed and could not be transformed, so non-parametric tests were used on these data. In all cases where multiple tests were conducted on the same data the significant P value was Bonferroni corrected; P is divided by the number of tests conducted to give P' [44].

All woodland and landscape variables (Table 1) were checked for intercorrelation using Spearman correlation coefficients. LIANA was highly correlated with IVY, ISO2 with ISO20 and HUMAN with MANAGE. Where such variables were highly correlated (r>0.7) the variable that contributed least when individually entered in to the logistic regression model described below was automatically discarded. Logistic regression was used to produce a model that best explained the differences observed between woods where yellow-necked mice were present or absent, based on the variation in the variables we measured. Initially the variables were entered individually into the model and variables where the probability of the Wald statistic was P>0.25 were not included in the main logistic regression. In the analysis LIANA, ISO2 and HUMAN were omitted. The remaining variables were entered simultaneously and a predictive model for yellow-necked mouse presence was produced based on the most influential habitat variables.

The country was split into 6 nominal regions appropriate to our current understanding of the yellow-necked mouse distribution (Figure 1) so that regional differences could be explored.
The trapping start date for each wood was recorded and considered in the analysis. Woods were placed in 6 shorter trapping windows, which represented consecutive fortnights through the survey period. The only exceptions to this were in the first and last time periods where two woods were included that were surveyed just before and just after the main survey period. Individually, none of the habitat variables measured showed a significant variation with the date of surveying.

Figure 1. Regional areas.

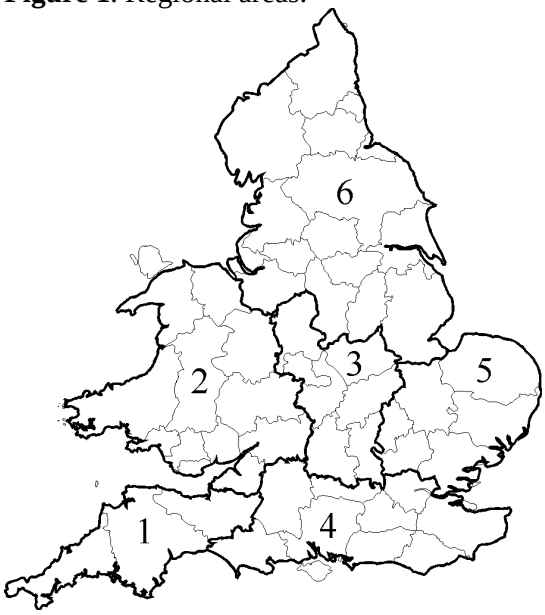


Table 2. Survey capture totals.
(Traps set on day 1 and checked on days 2 & 3)

Species	Day 2	Day 3 (New)	Day 3 (Recaps.)	Total
Wood mouse (*Apodemus sylvaticus*)	1334 *(42.9 %)*	1338 *(43.6 %)*	435 *(14.0 %)*	3107
Bank vole (*Clethrionomys glareolus*)	231 *(39.8 %)*	300 *(51.7 %)*	49 *(8.4 %)*	580
Yellow-necked mouse (*Apodemus flavicollis*)	206 *(42.1 %)*	232 *(47.4 %)*	51 *(10.4 %)*	489
Common shrew (*Sorex araneus*)	52 *(43.7 %)*	54 *(45.4 %)*	13 *(10.9 %)*	119
Pygmy shrew (*Sorex minutus*)	11 *(44.0 %)*	14 *(56.0 %)*	0	25
Water shrew (*Neomys fodiens*)	1	2	0	3
House mouse (*Mus musculus*)	0	2	0	2
Brown rat (*Rattus norvegicus*)	0	1	0	1
			Total:	4326

Results

Results Summary

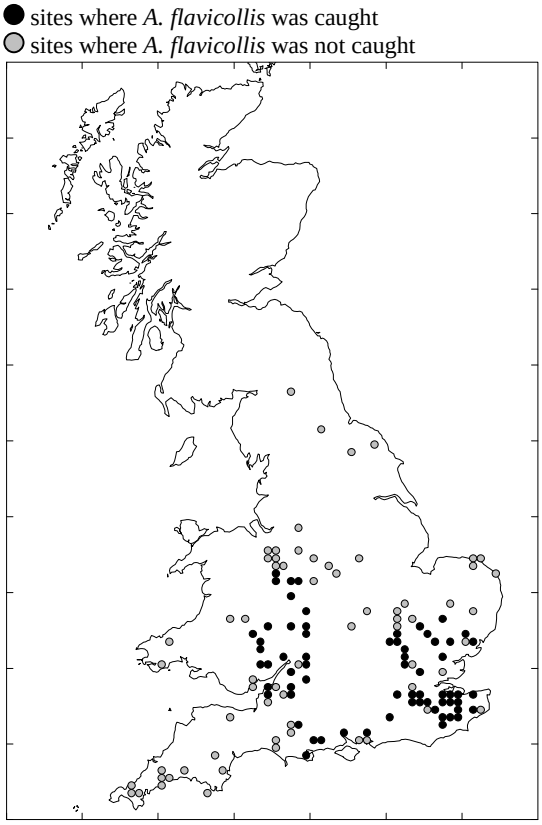
- 80 out of 168 woods surveyed contained YNM, including 71% of the sites that lay within the current range of this species.
- Where found together, YMN outnumbered WM in 15% of sites
- Trend for greater YNM abundance in the west of Britain
- YNM populations had a greater proportion of breeding females than WM populations.
- For WM, a lower proportion of breeding males and heavier non-breeding animals were found in woods without YNM.
- YNM populations were equally distributed between W8 and W10 woodland classes. All W12 woodlands surveyed contained YNM.
- YNM found in woods of all ages but more common in woods of ancient origin.
- Woods 2000+m from neighbouring wood >20ha were less likely to contain YNM.
- Less tree based ivy and more management activity were good predictors of the presence of YNM.

The categories of presence or absence for yellow-necked mice determined from this survey are likely to contain a number of misclassifications. The use of presence and absence in these results should be viewed in this light.

Small mammal captures

A total of 4326 small mammal captures were made during the survey and eight species were represented (Table 2). Wood mice were by far the most abundant woodland rodent representing 71.8% of all captures, followed by bank voles, *Clethrionomys glareolus* (13.4%) and yellow-necked mice (11.3%). Only these three species are considered in the analysis. Rodent captures increased on the second night of trapping (57.6% of total) with the overall capture of new animals (44.9%) slightly greater than that on night one (42.4%).

Figure 2. Survey distribution map.



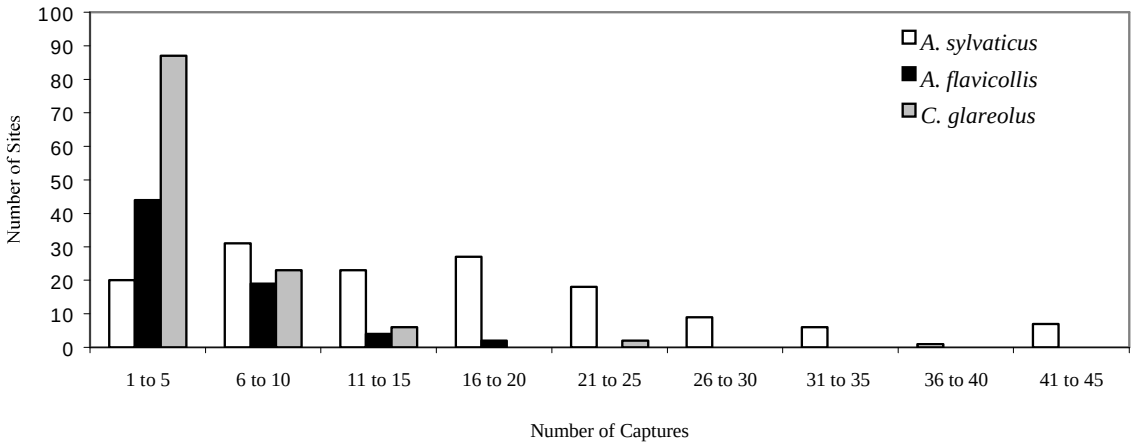
Wood mice were recorded in 164 woods, while yellow-necked mice were found in 80 woods (Figure 2) and bank voles in 124 woods. The mean abundance of all three species is shown in Table 3 for all woods, woods where yellow-necked mice were present and woods where yellow-necked mice were absent. There was no significant difference in the abundance of either wood mice (*t*-test; t=0.40, n=145, NS) or bank voles (Mann-Whitney; U = 2232.0, n=144, NS) between those sites where yellow-necked mice were present or absent. Captures of yellow-necked mice out numbered wood mice in 12 woods (15% of sites, n=80), with an equal index of relative abundance recorded at three sites.

Regional variation

Relative abundance

Yellow-necked mice were recorded from sites within the eastern, western, central and southern regions as defined in Figure 1. The two sites in the central region where yellow-necked mice were caught were at the far western side on the

Figure 3. Capture number frequency.



Staffordshire and Shropshire border. The mean abundance of yellow-necked mice was significantly different between regions (Kruskal-Wallis ANOVA, H=16.83, d.f. =5, P<0.01) (Table 3). However, when only the 4 regions in which this species was represented were examined, no significant affect of region on abundance was found (Kruskal-Wallis ANOVA; H=4.063, d.f. =3, NS). The trend appeared to be for higher numbers of yellow-necked mice in the west, although this was not significant. The mean relative abundance of wood mice was not found to be affected by region.

Presence or absence

The presence or absence of yellow-necked mice within woods was also examined for each region (Figure 4). Yellow-necked mice were present in 63% of sites in the southern region, 55% of sites in the west and 47% of sites in the east. The southern region was dominated by the large number of sites surveyed in Kent. No yellow-necked mice were found in sites in the south-western or northern regions.

Sites were also described more finely in to the categories of (a) within range, (b) outside range or (c) range border, based on the current known distribution of the yellow-necked mouse. In total 92 sites were categorised as "within range" and yellow-necked mice were trapped in 71% of these sites. There were 54 sites in the "range border" category of which 28% contained yellow-necked mice. No yellow-necked mice were caught in any of the 22 sites categorised as "outside range".

Interspecific differences

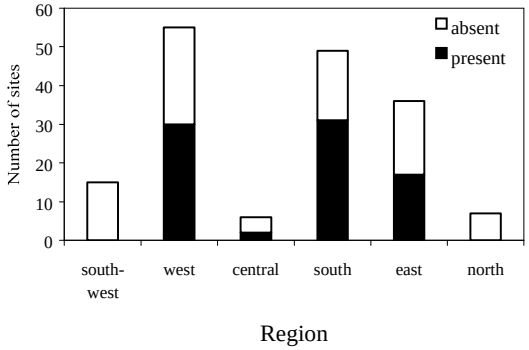
Sex ratio

Taking all the sites together, there was a significant difference in the sex ratio between captures of yellow-necked mice and bank voles (X^2=10.19, d.f. =1, P<0.01). In populations of yellow-necked mice more males (60.0%) than females were caught (40.0%), while the opposite was true for bank voles. There was no significant difference between the sex ratio in wood mice and yellow-necked mice.

Age structure

There were significant differences in the ratio of adult to pre-adult captures between yellow-necked mice and wood mice (X^2 =34.65, d.f. =1, P<0.001) and yellow-necked mice and bank vole (X^2 =32.99, d.f. =1, P<0.001) populations. In both cases, proportionately fewer pre-adults were recorded for yellow-necked mice (18.9% pre-adults for yellow-necked mice, 33.8% for wood mice and 37.6% for bank voles).

Figure 4. Presence or absence of *A. flavicollis* at sites from each region.



Breeding condition

Taking all animals classified as adults only, the ratio of breeding to non-breeding female yellow-necked mice recorded was significantly different from that of wood mice (X^2=12.15, d.f. =1, P<0.01) and bank voles (X^2=14.23, d.f. =1, P<0.001). 74.5% of female yellow-necked mice were in breeding condition, far higher than the figures for wood mice (55.6%) or bank voles (49.1%). In contrast, there were proportionately fewer male yellow-necked mice in breeding condition than was the case in bank vole populations (X^2 =11.96, d.f. =1, P<0.01). No difference existed between male yellow-necked mice and male wood mice.

Weight

The mean weights of all captures, adults and pre-adults for the three dominant species are shown in Table 4 and the age class weight distributions in Figure 5.

Intraspecific differences in woods where yellow-necked mice were present and absent

Sex ratio, age structure & breeding condition

There was no significant difference in the overall sex ratio for wood mice in those woods where yellow-necked mice were present and those sites where they were absent. However, a lower proportion of breeding to non-breeding adult males was recorded in woods where yellow-necked mice were present (X^2 =4.993, d.f. =1, P<0.05). There was no significant difference in the pre-adult to adult ratio in wood mice between woods with and without yellow-necked mice.

Weight

There was no significant difference in the mean weight of wood mice in woods with and without yellow-necked mice. However, interesting trends were apparent and further more complex analysis of these weights is planned.

Effects of landscape and habitat variables

Woodland vegetation classification

The National Vegetation Class (NVC) of the woodland was described for 150 of the 168 sites. Of these, 118 of the sites were equally distributed between the W8 (*Fraxinus excelsior - Acer campestre - Mercurialis perennis* woodland) and W10 (*Quercus robur - Pteridium aquilinum - Rubus fruiticosus*) classes. The presence and absence of yellow-necked mice was also equally distributed between sites in these NVC classes, with the species trapped in 51% of both W8 and W10 sites. All nine of the sites classified as W12 (*Fagus sylvatica - Mercurialis perennis* woodland) were found to contain yellow-necked mice. A further 15 sites were variously described including W14, W15 and W16 woodlands.

Woodland age

The planting date was only provided for 38 sites and these sites were grouped, as either (a) pre-1800s, (b) 1800-1900, (c) 1900-1950, (d) 1950-present or (e) mixed dates. Only one of the 7 sites classified as planted in the last 50 years was found to contain yellow-necked mice. The classification of sites as recent woodland (RW), ancient replanted woodland (ARW) or ancient semi-natural woodland (ASNW) was provided for 151 of the sites. Yellow-necked mice were found in 33% of RW sites, 52% of ARW sites and 53% of ASNW sites. When ARW and ASNW sites were combined to make one group of "ancient origin" there was a significant difference in the presence or absence of yellow-necked mice between this new class and the RW class (X^2=4.34, d.f. =1, P<0.05). Yellow-necked mice were found more often in the ancient woodland sites than in the recent woodland sites.

Woodland size

The area of the woodlands surveyed was recorded and subsequently the sites were also categorised as small, 2-10 ha (35%); medium, 11-30 ha (24%); large, 31-100 ha (25%) or extra large, >100 ha (16%). There was no significant effect of woodland size on the presence or absence of yellow-necked mice. Yellow-necked mice were recorded in between 46% and 57% of woods from all four size categories.

Woodland isolation

The vast majority of woodland sites were within 500m of the nearest woodland larger than 2ha in size (92%). The distance to the nearest 20+ha

Table 3. Mean relative abundance for entire populations, woods with and without *A. flavicollis* and for each region. Woods with potentially inaccurate abundance estimates were excluded. (Figures in brackets represent the values when only woods in which the given species was found, were included).

	A. sylvaticus			***A. flavicollis***			***C. glareolus***		
	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.	n
Entire population	16.03	10.45	142	2.45	3.89	142	3.28	4.10	139
	(16.26)	*(10.35)*	*(140)*	*(5.04)*	*(4.26)*	*(69)*	*(4.34)*	*(4.20)*	*(105)*
Woods									
A. flavicollis present	15.62	10.16	69				4.12	5.12	67
	(15.62)	*(10.16)*	*(69)*		n/a		*(5.11)*	*(5.25)*	*(54)*
A. flavicollis absent	16.41	10.78	73				2.50	2.64	72
	(16.87)	*(10.56)*	*(71)*				*(2.52)*	*(2.49)*	*(51)*
Region									
South-west	16.56	8.69	9	0	0	9	4.78	4.06	9
	(16.56)	*(8.69)*	*(9)*	-	-	*(0)*	*(6.14)*	*(3.48)*	*(7)*
West	15.60	10.46	45	3.42	4.44	45	3.69	4.81	45
	(15.60)	*(10.46)*	*(45)*	*(5.92)*	*(4.39)*	*(26)*	*(5.19)*	*(4.99)*	*(32)*
Central	19.20	6.91	2	2.00	4.47	5	1.40	1.67	5
	(19.20)	*(6.91)*	*(2)*	*(10.00)*	(-)	*(1)*	*(2.33)*	*(1.53)*	*(3)*
South	13.89	9.27	44	2.67	3.50	44	2.41	3.08	44
	(14.55)	*(8.96)*	*(42)*	*(4.19)*	*(3.64)*	*(27)*	*(3.31)*	*(3.17)*	*(32)*
East	19.65	12.36	34	2.09	4.01	34	3.71	4.61	31
	(19.65)	*(12.36)*	*(34)*	*(4.73)*	*(4.95)*	*(15)*	*(4.42)*	*(4.72)*	*(26)*
North	10.00	6.78	5	0	0	5	3.80	2.59	5
	(10.00)	*(6.78)*	*(5)*	-	-	*(0)*	*(3.80)*	*(2.59)*	*(5)*

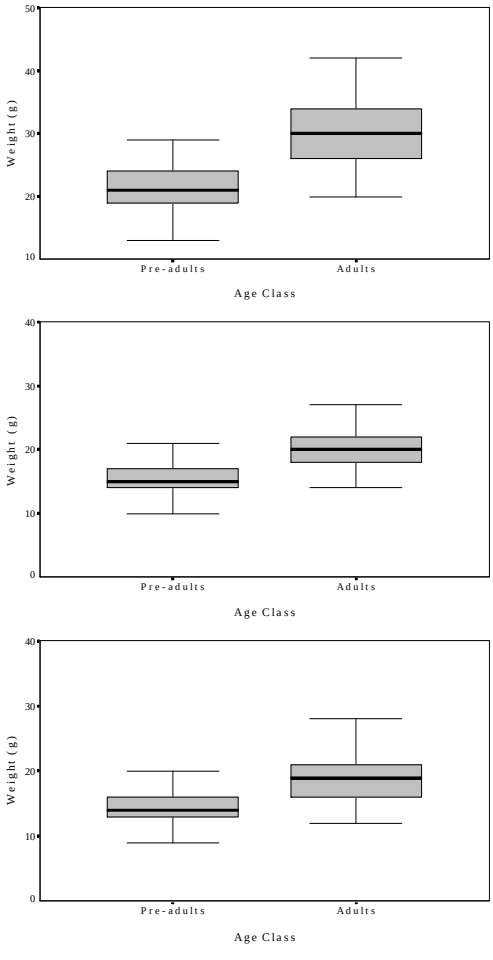
Table 4. Mean weights.

	Mean Weight (g)	SD	Min.	Max.	n
A. sylvaticus					
All	18.75	3.95	6.00	33.00	2301
Adults	20.42	3.51	14.00	33.00	1469
Pre-adults	15.46	2.56	6.00	21.00	754
A. flavicollis					
All	28.02	5.98	13.00	50.00	402
Adults	29.93	5.09	20.00	50.00	302
Pre-adults	21.26	3.84	13.00	29.00	85
C. glareolus					
All	17.38	3.81	7.00	35.00	472
Adults	19.02	3.55	12.00	35.00	286
Pre-adults	14.52	2.35	7.00	20.00	170

Table 5. Results of logistic regression analysis comparing habitat and landscape variables in woods where *A. flavicollis* was present and absent.

Variable	Coefficient*B*	S.E.	Wald	d.f.	*P*
Constant	2.961				
MANAGE	0.619	0.206	9.020	1	0.003
IVY	-0.546	0.257	4.501	1	0.034

Figure 5. Age class weight distributions A. *flavicollis* (top), *A. sylvaticus* (middle), *C. glareolus* (bottom).



woodland (ISO20) showed a greater variation between sites. All five classes of isolation (<100m, 101-500m, 500-1000m, 1001-2000m and 2000+m) were represented by between 25 and 33 sites. Yellow-necked mice were significantly less likely to be present in sites isolated from neighbouring woods (>20ha) by more than 2000m, than from sites where this isolation distance was less than 2000m (X^2 =4.88, d.f. =1, P<0.05).

Correlation and regression analysis

The abundance indices for yellow-necked mice were heavily weighted towards lower numbers (see Figure 3) and could not be transformed to fit a normal distribution. Abundance for this species was individually correlated with all woodland and landscape variables using Spearman correlation coefficients. Two variables were significantly correlated with abundance, ivy (*Hedera helix*) cover on trees (IVY) (r=-0.221, n=165, P<0.01) and the level of management activity (MANAGE) (r=0.188, n=164, P<0.05).

The variables ISO20, MANAGE, IVY, HERB, CANOPY, AGE and NVC were selected for the logistic regression analysis and entered simultaneously into the model. The model (-2LL=134.374, model X^2 =47.040, d.f. =11, P<0.001) correctly classified 73% of sites for the presence or absence of yellow-necked mice using the variables included. The two variables that were found to be significant in this model were MANAGE and IVY (see Table 5). The presence of yellow-necked mice was positively correlated with the level of management activity seen and inversely correlated with the amount of tree based ivy recorded.

Discussion Summary

- The YNM was widespread within suitable woodland inside its known range.
- The current distribution of the YNM is broadly supported by the survey, although additional records mean minor alterations.
- YNM may be the dominant woodland rodent more often than previously thought.
- There is no evidence that the YNM is of major conservation concern, although its status may be of local importance.
- There is some evidence that male YNM may affect breeding status in male WM.
- Woodland of ancient origin is more likely to contain YNM than recent woodland, although this was not exclusively the case.
- There is no evidence that sensitive woodland management practices are detrimental to YNM, in fact the opposite may be true.
- Tree based ivy cover was found to be inversely related to the presence and abundance of YNM, although reasons for this are unclear.
- Further work is needed to explore the factors determining the critical level of woodland isolation important to YNM.
- Central counties require further survey work to investigate local distribution.

Discussion

The yellow-necked mouse was the third most abundant rodent in this woodland survey, representing 11.3% of all captures, only marginally below bank voles (13.4%). Found in nearly half the 168 woodlands surveyed, the yellow-necked mouse clearly remains an important woodland rodent species.

Methodological discussions

The abundance indices obtained in this study are believed to be a valuable, if a somewhat blunt instrument for examining population trends in woods across the country. This was an exploratory study intended to provide a snap shot of the current status of yellow-necked mice in Britain and to explore the relevance of

various habitat and landscape features in explaining the abundance and distribution of this species. The trapping methodology would not be appropriate for monitoring long term changes at the individual site level, as inter-annual effects may be marked. The inclusion by some surveyors of an evening round trap (as previously described) is likely to have introduced a small variation in trap effort as animals released that evening could potentially be recaptured in other traps the following morning. In practice this variation was thought to be negligible and certainly no greater than other sources of variation, such as the occasional animal that escaped before marking.

Missing data were a fairly common feature of this survey, often indicative of the level of experience of surveyors. However, the great majority of the recording appeared to be conducted with considerable care and the magnitude of the survey ensured that a large dataset was produced.

Distribution

The distribution of sites in southern England and Wales and the pattern of presence and absence seen, generally supports the current described range for this species[1]. Exceptions to this are new records for Staffordshire and Bedfordshire which extend the edge of its current range, and those from parts of Cambridgeshire, north-east Kent and Shropshire which are important in clarifying more speculative parts of the distribution map. Many other new records within its accepted range have also been generated. Within the accepted distribution of this species 71% of sites surveyed were found to support populations of yellow-necked mice. This confirms that the yellow-necked mouse may be quite widespread within suitable woodland within its natural range. None of the sites believed to lie outside the range of the yellow-necked mouse were found to harbour populations of this species. To some extent, this should help to dispel speculation that the distribution seen for the yellow-necked mouse is an artefact of low trapping effort.

However, this is not to say that we know the exact range of the yellow-necked mouse in Britain. In some cases information on local populations is still very patchy. In Devon and Cheshire for example, despite the absence of current records prior to or during this trapping survey, recent but unsubstantiated records have since been received[45]. A more sustained monitoring programme will be needed to verify their presence and assess their local abundance and distribution. Counties in central England are very poorly represented by records and require considerable further survey work to elucidate the local status of the yellow-necked mouse.

Previous studies have suggested that yellow-necked mice may be more common in the arable areas in eastern England [36,46]. These data do not support this. This study shows that fewer of the woodlands surveyed in the eastern region (see Figures 1 & 2) contained yellow-necked mice than those in the south or west. This result could be an artefact resulting from the sites selected or from the regional divisions chosen. Sites from Kent make up a large proportion of the southern region sites and this was obviously an excellent area as regards the presence of yellow-necked mice. However, the relative abundance indices also suggest a trend towards larger populations of this species in the west. Overall, these data suggest that this species is equally, if not more, abundant in the western part of its British range.

A separate collection of yellow-necked mouse records has also been conducted in parallel to the trapping survey. These will be included in a comprehensive analysis of the current distribution of this species to be completed later this year. The questionnaire “A Mouse In Your House?” has also revealed a number of interesting records and once verified these will be included in this analysis.

Relative Abundance

Taking all the sites, there was no significant difference in the relative abundance of wood mice or bank voles in woods where yellow-necked mice were found compared with woods where they were not trapped. This supports the findings of more localised studies where no interaction has been shown between the abundance of wood mice and yellow-necked mice [43]. However, although yellow-necked mice have been shown to exist in greater numbers

than wood mice on some occasions [19,43,47], it has been commonly believed that these represented exceptional sites or events. In this survey yellow-necked mice had a higher relative abundance than wood mice at 15% of sites where the two species were found living sympatrically. Even taking into account the potential inaccuracy of these indices this does suggest that in suitable woodland yellow-necked mice may be the dominant species more often than was previously thought.

Interspecific differences

Yellow-necked mouse populations were found to contain fewer pre-adults than wood mice (or bank voles). This was despite the fact that during the three month survey period the percentage of breeding wood mice fell heavily to lower levels about two weeks prior to yellow-necked mice, which suggests that the latter's breeding season continued for longer. Although the age classifications made as part of this survey must be regarded with some care, one might expect any misclassifications to be spread among all species and this should not therefore alter the result observed here. Differences in the breeding condition of animals were also seen with significantly more female (but not male) yellow-necked mice in breeding condition than in wood mice or bank voles. This may be attributable to the extended breeding period observed.

Intraspecific differences

The structure of wood mouse populations in woods with and without a yellow-necked mouse population is of particular importance in examining the potential affects of sympatry. It has long been suggested that competitive interactions are likely to occur between these two species[21], although how this manifests itself is an enduring mystery. In this study, a lower ratio of breeding to non-breeding males was observed in woods where yellow-necked mice were present, possibly attributable to interspecific male-male interactions. Male yellow-necked mice may curtail or inhibiting the acquisition of breeding status in male wood mice, but which if either of these is the case is unclear.

Landscape and habitat effects

The National Vegetation Class (NVC) of each woodland was assessed as a means of standardising woodland descriptions. Deciding upon the correct NVC class was not always straightforward. However the great majority of woodlands surveyed were either W8 (*Fraxinus excelsior - Acer campestre - Mercurialis perennis* woodland) or W10 (*Quercus robur - Pteridium aquilinum - Rubus fruiticosus*). There was no difference in the presence-absence or abundance of yellow-necked mice between these classes which confirms that these common deciduous woodland types both provide suitable habitat for this species. Similarly, all nine of the W12 (*Fagus sylvatica - Mercurialis perennis*) woodlands surveyed were found to host yellow-necked mouse populations. Even with this small sample size it suggests these beech woods may be important, particularly in this autumn period where beech mast may be a valuable source of food [48].

The age of the woodland has long been believed to be important to populations of yellow-necked mice; mature deciduous woodland is the favoured habitat [19,20,21]. These data provide one of the first opportunities to explore these ideas on more than a localised scale. Yellow-necked mice were represented in woods classified as ASNW, ARW and RW. However, a significantly greater proportion of woods in the ASNW and ARW classes contained yellow-necked mice than the RW class. These results show that woodland of ancient origin is more likely to contain yellow-necked mice than recent woodland but that these categories alone cannot accurately predict the presence or absence of this species. As previously shown[43], relatively recent woodland can still provide habitat that is utilised by yellow-necked mice and this was supported by the finding that four of the seven woods planted between 1900 and 1950 contained populations of this species. This suggests woodland may not have to be that old to benefit yellow-necked mice, at least during this autumn period when they are at their peak abundance. Only one of the seven sites planted since 1950 contained populations of this species, which tentatively confirms that this very immature woodland is not ideal for yellow-necked mice.

Woodland size was not found to be an important factor in predicting the likely presence or absence of yellow-necked mice, supporting previous work[43]. The distance of the site from the nearest large neighbouring woodland (>20ha) was important. Woodlands isolated by more than 2000m from the next significant woodland block were less likely to contain populations of yellow-necked mice. This is the first time that an isolation effect due to habitat fragmentation has been shown for this species, although it has been predicted that this species may be susceptible to such effects[32]. Since these distances were measured from maps, good information on the age or habitat type of the neighbouring woodlands was not available. Further studies are needed to establish greater detail on the factors important to this habitat fragmentation effect and to try to determine the critical isolation distance that may inhibit dispersal to neighbouring sites. In particular, differences between arable and pastoral landscapes would be an obvious area for investigation, since hedgerow patterns and connectivity may be very different in these areas.

Within these woodland sites management level and the amount of ivy on trees were found to be useful in predicting the presence or absence of yellow-necked mice. The less ivy seen, and the higher the level of management, the greater the likelihood of finding yellow-necked mice. Both these results were at odds with initial hypotheses that yellow-necked mice would prefer sites showing least disturbance and greater ivy cover to promote arboreal movement.

Ivy is the only British member of the tropical family Araliaceae and its growth is strongly temperature dependent, displaying late flowering and great sensitivity to frost[49]. As a result of this stems rarely grow up in to the trees in the colder east and north of the country in the way they do in the west. The regional variation in tree based ivy scores from this study showed just this expected variation, with the south-western and western woodlands displaying higher mean scores than the eastern and northern sites. The apparent significance of climbing ivy in explaining the presence or absence of yellow-necked mice might therefore be representative of regional differences in other factors, possibly climatic parameters, although a satisfactory explanation is not immediately apparent. The presence and abundance of yellow-necked mice was actually found to be higher in the western rather than eastern region and this runs contrary to the suggestion from this piece of the analysis. Climatic effects on the distribution and abundance of the yellow-necked mouse are being investigated in the second phase of this analysis and this may reveal factors that help to explain these findings.

The result for woodland management level was equally interesting. A high management score awarded to a wood did not necessarily indicate the type of disturbance that would be detrimental to yellow-necked mice or other rodents. Recent evidence of felling, clearing or coppicing would have resulted in a high management score and these practices may, when carried out sensitively, enhance the woodland habitat. It is known that yellow-necked mice avoid very recent coppice[26] but the presence of coppice cycling also indicates the presence of hazel, a favourite food source. Well maintained coppice and a variety of different microhabitats within the wood maintained by practices such as scrub removal or ride widening may well be beneficial to yellow-necked mice, perhaps by providing a wider range of food sources through the year. This is an important first indication that sensitive woodland management practices, largely to benefit a range of other flagship species, may also benefit yellow-necked mice, or at least not be detrimental to this species. Intensive tree removal or other types of habitat degradation are clearly a separate issue. Woodlands that are regularly managed naturally tend to be older woods (and often in this survey nature reserves) which are often preferred by this species[20] and this may be another explanation why the presence and absence of yellow-necked mice was partially explained by this variable.

The Future

This survey was run for one year as an exploratory exercise to see whether there were enough volunteers to undertake such a

widespread trapping project. The answer to this question is obvious: yes! A large amount of very valuable data were collected, and these revealed a lot of new information about the yellow-necked mouse.

The survey has also revised some of our ideas about yellow-necked mice, and at present there is no evidence that the species is of major conservation concern. However, there must be some caveats in this statement. First, the data were collected in a single autumn, and so we do not know if this was a particularly good or bad year for yellow-necked mice, or whether this was a typical year. Secondly, the fragmentation effect identified by this study does mean that populations of yellow-necked mice may disappear from some of the more isolated woodlands.

Having learnt a great deal from this survey The Mammal Society will do some detailed work on yellow-necked mice shortly. The aims of the second part of the project will be to get a better understanding of the habitat needs of yellow-necked mice, their densities on the fringes of their range, and the precise limits of their distribution. I hope you will be able to participate in this project. Meanwhile, the next trapping project - starting this autumn - is likely to be a survey of small mammals in roadside verges.

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