The distributions and habitat associations of *Hyloniscus riparius* (C. Koch) and *Trachelipus rathkii* (Brandt) at a floodplain meadow on the River Avon, Worcestershire

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Abstract

The distributions of the woodlouse *Hyloniscus riparius* (C. Koch) and associated species were surveyed at a floodplain meadow site in Worcestershire comprising hedgerows, and grasslands with varying amounts of rush tussocks. The most abundant associate was *Trachelipus rathkii* (Brandt). Both species were found in piles of flood debris immediately adjacent to the river, in debris beneath a hedgerow, and in the bases of rush tussocks within the meadow. *Hyloniscus riparius* was strongly associated with flood debris, both within discrete piles of debris immediately adjacent to the river and within debris deposited adjacent to, and within, a hedgerow. A small number of individuals were also found within rush tussocks in the floodplain meadow. Within piles of debris, numbers of *H. riparius* were positively related to the depth of material. In contrast, numbers of *T. rathkii* were unrelated to the depth of material and overall, the species was less strongly associated with flood debris; being equally frequent within rush tussocks. Contrasting the species' distributions indicates that *H. riparius* is more sensitive to moisture levels within its microhabitat. The survey also suggests that *H. riparius* may have the capacity to spread from its riparian stronghold to other habitats provided a suitably moist microhabitat comprising dead plant material is present at the soil surface. As part of the survey, a method using refugia made from rolled tubes of corrugated cardboard was found to have potential for detecting the presence of *H. riparius*, particularly when the refugia were dampened.

Introduction

The riparian woodlouse *Hyloniscus riparius* (C. Koch), is a small soil-surface dwelling Trichoniscid, or pygmy, woodlouse associated with moist, organic-rich microhabitats (Farmer, 2022). The species is native to Central and Eastern Europe but has been introduced to areas of Russia, Northwest Europe, and North America through anthropogenic activity (Gregory, 2024a). The species was recorded as new to the United Kingdom in 2022 (Farmer, 2022). Studies in Russia and the United States of America suggest that *H. riparius* has negative impacts on native and established terrestrial isopod species (Gongalsky *et al.*, 2013). Competitive interactions have not been reported from Western Europe, although the species appears to be expanding its range with new records from Belgium, Netherlands, and north-west France (reviewed in Gregory & Farmer, 2023).

The first record of *H. riparius* in the UK was at Haines Meadow, one of a series of floodplain meadows, known as Lower Moor River Meadows (LMRM) (Vale Landscape Heritage Trust, 2024), adjacent to the River Avon in Evesham, Worcestershire (Farmer, 2022). It was subsequently found at additional sites nearby and at Evesham Country Park about 8km upstream (Gregory, 2024a). In Europe, a frequent associate of *H. riparius* is *Trachelipus rathkii* (Brandt). Both species are tolerant of seasonal inundation (Farkas & Vilisics, 2008), and they co-occur at LMRM (Gregory, 2024a).

Trachelipus rathkii has a south-eastern distribution in the UK but is expanding its range and was discovered at LMRM two years prior to *H. riparius* (Farmer, 2021). The more widespread occurrence of *T. rathkii* suggests that *H. riparius* may be found elsewhere – especially as both species are thought to be spread through anthropogenic activity (Gregory, 2024a). Moreover, while at sites in Worcestershire, *Hyloniscus riparius* has, to date, been found only within riverside flood debris (Gregory, 2024a, b), it has been recorded more widely in Europe and the United States of America, for example in glasshouses, floodplain woodlands, and upland deciduous woodlots distant from water courses (Stoyenoff, 2001). The species' microhabitat is primarily the damp accumulations of dead plant material, moss or woody material at the soil surface (Farmer, 2022), hence a more widespread distribution might be anticipated within the UK with further searching.

The recent discovery of *H. riparius* at LMRM presents an opportunity to investigate its habitat requirements and associations with other woodlice in the UK, particularly *Trachelipus rathkii*. In this study, we report the results of a field survey conducted in 2025 at LMRM close to the original discovery site of *H. riparius*. Quantitative survey methods, involving timed searching by hand and cardboard tube refugia (Embry, 2020), were used to record the abundance of woodlice in flood debris, meadow grasslands, and hedgerows immediately adjacent to the River Avon.

Study site

The study site was at Lower Moor River Meadows (SO 975 467) adjacent to the River Avon in Worcestershire. *Hyloniscus riparius* was discovered in flood debris here and on the opposite bank, at Haines Meadows, in April 2022. At both locations, piles of flood debris had been deposited between the landward side of the raised riverbank and a post-and-wire fence separating the embankment from adjacent flood plain meadows (Farmer, 2022). At Lower Moor, the study site comprised the riverbank and the adjacent flood plain meadow bounded by hedgerows. Major habitats were mapped in the field and digitised using Arc GIS in November 2024 (Figure 1).

Figure 1: The study site at Lower Moor River Meadows adjacent to the River Avon. Habitats that were surveyed for woodlice are highlighted in colour.

The site comprised of three major habitats: a) rough grassland and scrub on the riverbank, b) hedgerows, and c) the flood plain meadow. The flood plain meadow was subdivided into three zones based on the frequency of tussocks of Hard rush *Juncus inflexus* and management. The zones within the meadow were a) a strip around three margins, mown annually, with no rushes (Figure 2), b) a central area, with an occasional hay crop being taken, and with more-or-less evenly scattered rush tussocks (approximately 25% cover) (Figure 3), and c) on the fourth side, an uncut margin dominated by rush (90% cover) (Figure 4). Hereafter, these zones within the meadow are referred to as grassland, sparse-tussock grassland, and dense-tussock grassland respectively (Figure 1). The meadow is grazed by cattle each summer, although the timing varies depending on the weather, extent of grass growth and the timing of any hay cut.

Figure 2: Floodplain meadow grassland lacking rush tussocks adjacent to the southern hedgerow (looking northeast in February 2025).

Figure 3: Floodplain sparse-tussock grassland (looking northwest towards the northern hedgerow in October 2025).

Figure 4: Floodplain dense-tussock grassland (looking northwest in October 2025).

In addition to Hard Rush, frequent species within the floodplain meadow were Tufted Hair-grass, *Deschampsia cespitosa*, Common Couch *Elymus (Elytrigia) repens,* Crested Dog's-tail *Cynosurus cristatus*, Meadow Fescue *Schedonorus pratense*, Rye Grass *Lolium perenne*, Cock's-foot *Dactylis glomerata* and Meadow Barley *Hordeum secalinum*, along with Common Sorrel *Rumex acetosa*, Creeping Buttercup *Ranunculus repens*, Dandelion *Taraxacum* agg., White Clover *Trifolium repens*, Spear Thistle *Cirsium vulgare* and Creeping Cinquefoil *Potentilla reptans*. Other characteristic species include Tubular Water-dropwort *Oenanthe fistulosa*, Meadowsweet *Filipendula ulmaria*, and Lady's Smock *Cardamine pratensis* (Vale Landscape Heritage Trust, 2024).

There was no cutting or grazing within the meadow during the study period. When the floodplain grassland was surveyed, the rush tussocks were up to 50cm in height. The grass sward between tussocks was approximately 5-10cm in height and lacked a thatch of dead plant material that typically builds up in ungrazed pasture.

The rough grassland on the riverbank is largely unmanaged save for occasional targeted cutting to maintain access along a footpath. Frequent species were Common Couch *E. repens*, Rye Grass *Lolium perenne*, Cock's-foot *D. glomerata*, Yorkshire Fog *Holcus lanatus*, Cow Parsley *Anthriscus sylvestris*, Stinging Nettle *Urtica dioica*, Hogweed *Heracleum sphondylium*, Bramble *Rubus fruticosus* agg., Dandelion *Taraxacum* agg., Greater Plantain *Plantago major*, Spear-leaved Orache *Atriplex prostrata*, Spear Thistle *C. vulgare*, and Wild Teasel *Dipsacus fullonum*. Scattered scrub comprised Willow *Salix* sp. and occasional Alder *Alnus glutinosa*.

The two hedgerows were approximately 3m tall and 5m wide with a post-and-wire fence on either side. The canopies comprised Hawthorn *Crataegus monogyna* and Blackthorn *Prunus spinosa* with occasional Dog Rose *Rosa canina*. Brambles *R. fruticosus* agg. and Nettles *U. dioica* dominated the ground flora.

The meadow was flooded from the 5th - 18th January 2025 and in the following week the distribution of freshly deposited flood debris was recorded. Piles of debris were noted in three locations: a) on the riverbank more-or-less at the same location observed by Farmer (2022) when *H. riparius* was first discovered (Figure 5), b) trapped against the fence between the meadow and the northern hedgerow (Figure 6), and c) within the interior of northern hedgerow. Piles on the riverbank were mapped as a distinct habitat (Figure 1).

Figure 5: Piles of flood debris deposited between the River Avon and adjacent floodplain meadow at Lower Moor River Meadows (left, looking southeast; right, looking northwest) in January 2025. The southern hedgerow can be seen beyond the enclosed grassland in the left image.

Figure 6: Piles of flood debris trapped against the fence along the edge of the northern hedgerow (looking northeast) in January 2025.

Methods

Survey overview

The main survey was carried out from 22nd January to 19th February 2025, with a smaller follow-up survey in June of the same year. Quantitative sampling in January and February used two methods: timed hand-searching within quadrats as recommended by the British Myriapod and Isopod Group (2024) and use of refugia in the form of cylindrical rolls of corrugated cardboard (Embry, 2020).

In January and February, hand-searching in quadrats was used to sample the riverside piles of flood debris and each of three meadow zones. Due to difficulties in accessing the interior of the hedges, refugia were used to survey the two hedgerows with the refugia being placed beneath the fences separating each hedgerow from the adjacent meadow (Figure 7).

Figure 7: Cardboard tube refugium placed beneath leaf-litter and flood debris.

In June, the follow-up survey employed both refugia and semi-quantitative hand-searching in the interior of the northern hedgerow and riverside debris piles. The purpose of this more targeted survey was twofold: first, to assess the relative efficacy of the tube refugia versus hand-searching, and second, to confirm the presence of *H. riparius* within the interior of the northern hedge following discovery of a single specimen in February. The following sections provide more detail about the surveys.

Weather during the survey period

Weather leading up to, and during, each survey is potentially important because the target species are sensitive to moisture levels.

In January, flood water receded four days before surveying with quadrats and refugia began. During the four-week sampling period, rainfall, temperature and sunshine hours were close to the long-term seasonal average (Meteorological Office, 2025a) with only occasional light rain at the study site (Fleming, personal observation). Flood debris piles felt dry at the surface, but deeper debris and the soil beneath remained damp to the touch. The weather on each of the dates when quadrats were searched was cool and overcast. The bottom of rush tussocks were damp on each survey session. Humidity in Evesham ranged from 87% to 100% on the 22nd and 29th of January, and from 76% to 87% on the 5th and 12th of February (Meteorological Office, 2025a).

The weeks leading up to, and during, the follow-up survey in June were unusually warm, dry and sunny compared to long-term averages (Meteorological Office, 2025b, 2025c). On 20th June when hand-searching, and placement of refugia, took place the weather was warm and dry. Flood debris had dried noticeably, and only debris at the soil surface retained moisture.

Timed quadrat hand-searching in January and February

Sampling using quadrats utilised a stratified random design. Ten quadrats were placed in each of the three meadow zones and riverside debris at weekly intervals for four weeks starting on 22nd and then 29th January, 5th and 12th February. The location of quadrats was determined using co-ordinates from a random number generator with the precise locations being pinpointed with GPS in the field. Within the two meadow zones characterised by the presence of rush tussocks, co-ordinates were used only if the quadrat contained a rush tussock. If no tussock was present, new co-ordinates were selected. New co-ordinates were generated weekly.

The quadrat (0.5m by 0.5m) was placed at each sample location and carefully searched for five minutes. Living plant material, leaf litter and flood debris (where present) was carefully searched down to the soil surface. In quadrats containing a rush tussock both the tussock and surrounding grass sward were searched. In quadrats placed in piles of flood debris on the riverbank, the depth of debris was measured by inserting a metal rod at the centre of the quadrat until there was resistance at the soil surface. The location of woodlice within the vegetation/debris profile was noted, along with their association with specific types of material (such as reed fragments, natural logs and sawn timber). Woodlice were identified to species in the field and released where found.

Sampling with refugia in January and February

Refugia were made of corrugated cardboard sheets based on a method originally described for sampling invertebrates on tree trunks (Embry, 2020; Salman *et al*., 2020). Cardboard sheets, 20cm by 83cm, were rolled into tubes that measured 20cm in length and 6cm in diameter. Sticky tape was used to prevent tubes unravelling.

The two hedgerows were sampled in January and February using refugia. Ten refugia were placed along the fence line bordering each hedge at weekly intervals. Refugia were deployed on the same days that quadrat samples were taken in the meadow and riverside flood debris piles. Placement of refugia was determined using randomly selected numbers to represent distance along the hedge with new numbers being generated each week. Refugia were placed at the soil surface below leaf litter and flood debris (where present) (Figure 7). Refugia were left in place until collected the following week when they were placed in individual plastic bags for examination in the laboratory. Woodlice were identified to species and preserved in 70% ethanol. Freshly made tubes were used each week.

Follow-up survey in June

The follow up survey in June was prompted by the discovery of a single specimen of *H. riparius* in one of the refugia placed at the fenceline of the northern hedge in February. Limitations of the earlier survey were that refugia were placed only at the margin of the hedges and that refugia and hand-searching were never used in tandem at the same locations. It was therefore uncertain whether a) the two methods were equally effective, b) the single specimen from the hedge was an isolated individual or part of a large population, and c) *H. riparius* occurred deeper into the hedge. To address these questions refugia were deployed within the interior of the northern hedge and within riverside debris piles. Sample sites were also searched by hand for ten to fifteen minutes to confirm the presence of *H. riparius* immediately before refugia were deployed. Any woodlice found were counted and identified in the field before being released where they were found. Refugia were left in place for seven days starting 20th June.

Five locations within the northern hedge and five locations within riverside debris piles were selected subjectively. Those within the hedge were chosen based on ease of access (limited by hawthorn, blackthorn, brambles and stinging nettles) and the presence of leaf litter and/or flood debris thought likely to favour the presence of *H. riparius*. The depth and type of litter material present was recorded. Placement within riverside debris piles was based on where *H. riparius* had previously been located in January and February.

Design of the refugia, their placement at the litter-soil interface, and subsequent collection followed the previously established protocol with a minor amendment. Tubes were placed in pairs at each of the ten sample sites. The weather in May and June had been unusually dry and therefore one tube in each pair was dampened to encourage woodlice to enter. Contrast between numbers caught in 'dry' and 'wet' refugia was planned to indicate if wetting the refugia was a helpful modification of the method.

Developmental stage and sex of *Hyloniscus riparius*

Twenty specimens of *H. riparius* were collected from the riverside piles of flood debris during a preminary site visit on 7th January to determine their developmental stage and reproductive status using BMIG (2024). Additional observations were made on specimens recorded during the sampling in January, February and 18 further specimens were collected in June. The identification of juvenile *H. riparius* is challenging due to the incomplete development of some diagnostic features such as sexual characteristics and size of specimens. To minimise the risk of misidentification, only juvenile individuals which exhibited clear diagnostic features, as defined by BMIG (2024) and Gregory and Farmer (2023), were included in the dataset. Any specimens that lacked sufficiently developed or visible features to allow for confident identification were excluded from the dataset and analyses.

Statistical methods

Statistical analysis was undertaken using SPSS version 29. Preliminary testing showed that data deviated from a normal distribution and therefore non-parametric tests were used. Relationships between variables were tested using Spearman's Rank Correlation. Differences in abundance of woodlice across habitat types and weeks were analysed using the Mann-Whitney U test and Kruskal-Wallis Analysis of Variance by Ranks test for independent samples. Comparison of numbers of woodlice in wet and dry tube refugia used Wilcoxon's Signed rank test for paired data.

Results

Species inventory

In the main January and February survey, totals of 670 *H. riparius* and 84 *T. rathkii* were recorded. The follow-up survey in June recorded a further 90 *H. riparius* and 10 *T. rathkii*. Other species of woodlice were recorded less frequently. These species were: *Trichoniscus pusillus agg.* Brandt, *Philoscia muscorum* (Scopoli), *Oniscus asellus* (Linné), *Porcellio scaber* Latreille and *Armadillidium vulgare* (Latreille) (Table 1).

The numbers of each species recorded in the main survey during January and February are shown in Table 1. It is not possible to directly compare numbers of individuals in hedgerows to those found in other habitats because a different sampling method was used. However, based on the number of habitats occupied, *T. rathkii* was the most widespread species, followed by *H. riparius* and *P. muscorum*. Most specimens of *H. riparius, T. pusillus agg., O. asellus* and *P. scaber* were recorded in flood debris piles. *Philoscia muscorum* was also recorded in flood debris piles, but more individuals were found in dense-tussock grassland (Table 1).

Table 1: Total numbers of woodlice recorded from each habitat during surveys in January and February. Each habitat was surveyed using a total of either quadrats or tube refugia at weekly intervals from 22nd January to 19th February 2025.

Species	Timed hand-searching				Refugia	
	Flood debris piles	Meadow: no tussocks	Meadow: sparse-tussocks	Meadow: dense-tussocks	Hedgerow - north	Hedgerow - south
H. riparius	670	0	1	2	1	0
T. rathkii	37	1	33	4	3	6
T. pusillus	5	0	0	0	0	0
P. muscorum	8	0	0	11	4	4
O. asellus	18	0	0	2	0	0
P. scaber	4	0	0	0	0	0
A. vulgare	0	1	0	0	0	4

The following sections focus primarily on the distributions of the two riparian species *H. riparius* and *T. rathkii* for which larger number of records were obtained (Figures 8 and 9). The former species was the most abundant and showed a strong affinity with piles of flood debris. *Trachelipus rathkii* was more widely distributed across the study site and showed an affinity with both debris piles and sparse-tussock grassland (Table 1).

Distribution of *Hyloniscus riparius* in January and February

In January and February, all but four specimens of *H. riparius* were recorded from the hand-searching of riverside flood debris (Table 1, Figure 8). Within the riverside flood debris piles, numbers per quadrat did not differ significantly between weeks ($H = 4.07$, d.f. = 3, $p = 0.25$). Numbers of individuals found per quadrat placed within the debris piles varied from 0 to 56 with a mean of 16.65 (Standard Deviation (SD) = 12.94) (N=40) equivalent to a density of 66.60 (SD = 51.76) per m^2.

Within flood debris piles, *H. riparius* were found mainly at the moist interface between the soil and bottom of the debris, but they were also associated with large pieces of wood. For example, thirty-eight individuals were found on a single log (length 37cm, diameter 26 cm) which had numerous cracks and crevices. No individuals were found within dense layers of tightly packed reed debris.

Of the four specimens found beyond the riverside flood debris piles, one was found in a refugium placed at the fenceline of the northern hedge and three were found by hand-searching in the bases of tussocks of *J. inflexus* in the meadow (Figure 8). All three 'tussock specimens' were found between the stems at the base of a tussock where moisture content was high. Two were in separate tussocks in the dense-tussock grassland, each with stems varying from 40 to 50cm, while the third specimen was within a tussock with stems varying from 10 to 40 cm tall, in the sparse-tussock grassland. No *T. rathkii* were found in these individual tussocks, although *T. rathkii* occurred in other tussocks within the meadow. The three tussocks and single hedgerow refugium which each yielded a single *H. riparius* were 125 m, 144 m, 194 m and 213 m from the main population located in the large piles of riverside flood debris (Figure 8).

Distribution of *Trachelipus rathkii* in January and February

In January and February, *T. rathkii* was found to be less abundant yet more widely distributed than *H. riparius* (Figure 9). The species was found by both sampling methods and within each of the habitats surveyed. The species showed a tendency to be more abundant in refugia than *H. riparius*, although numbers in tubes were low (Table 1). The majority of *T. rathkii* were found by hand-searching, with

Figure 8: The distribution of sample points where *Hyloniscus riparius* was recorded in January and February 2025. In total, 666 *H. riparius* were found in the riverside flood debris piles (shaded yellow) hence these locations are not shown individually. Four individuals found beyond the riverside debris piles are shown as dots according to the habitat in which they were found.

Figure 9: The distribution of sample points where woodlice species, other than *Hyloniscus riparius*, were recorded in January and February 2025.

only 9 out of 84 specimens being found in refugia. Moreover, of the total of 75 specimens recorded by hand-searching, 37 and 33 were found in flood debris piles and sparse-tussock grassland respectively (Table 1). The species was more abundant than *H. riparius* in sparse-tussock grassland, but less abundant in flood debris.

Within the riverside debris piles and sparse-tussock grassland average numbers of *T. rathkii* per quadrat did not differ between weeks (debris, H = 4.82, d.f. = 3, p = 0.19; sparse-tussock grassland, H = 5.21, d.f. = 3, p = 0.16). Average numbers per quadrat also did not differ significantly between flood debris and sparse-tussock grassland (Mann-Whitney test, U = 707.0, p = 0.30). Overall, across these two habitats, the maximum number of *T. rathkii* per quadrat was 8 with a mean of 0.88 (SD = 1.56) (N = 80) equivalent to a density of 3.52 (SD = 6.24) per m^2.

The distribution of *T. rathkii* within piles of flood debris mirrored that of *H. riparius* with most individuals being found at the moist interface between the soil and debris. As with *H. riparius*, they were also found on large pieces of wood.

Associations between depth of flood debris, *H. riparius* and *T. rathkii*

Within the riverside flood debris piles, *H. riparius* and *T. rathkii* tended to be more abundant in moister layers close to the soil, but there was no correlation between their numbers within samples (r_s = -0.04, p = 0.80, N = 40). The abundance of *H. riparius* was strongly positively correlated with the depth of the debris (r_s = 0.71, p <0.001, N = 40) (Figure 10) whereas this was not the case for *T. rathkii* (r_s = 0.17, p = 0.30, N = 40). For *H. riparius* the significant positive correlation between numbers and depth of debris was seen in three out of the four weeks (week 1, r_s = 0.26, p = 0.46; week 2, r_s = 0.83, p = 0.003; week 3, r_s = 0.83, p = 0.003; week 4, r_s = 0.86, p = 0.002; N = 10 for each week) (Figure 10).

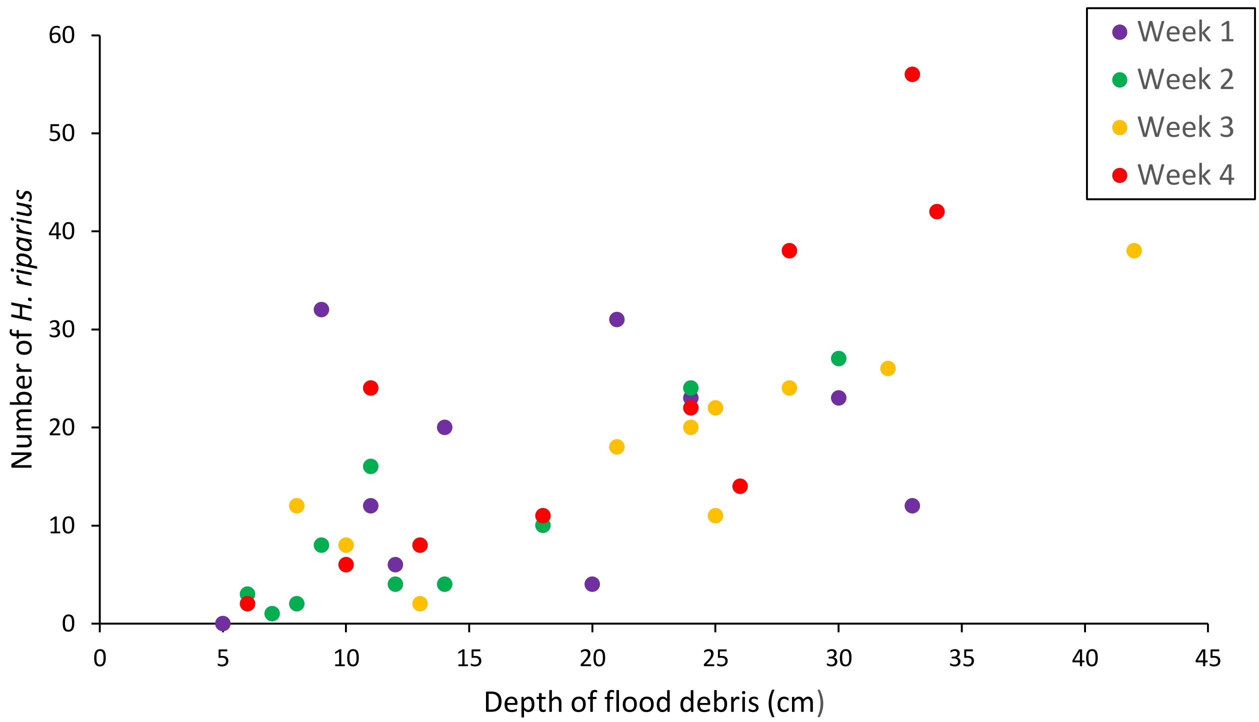

Figure 10: The relationship between numbers of *Hyloniscus riparius* recorded by hand-searching within quadrats placed on riverside flood debris piles and the depth of the debris. Weeks refer to sampling dates at seven-day intervals starting 22nd January 2025 (N=10 quadrats per week).

Follow up survey in June

Six species were recorded in the hand-searches of debris piles and the hedgerow (Table 2). Compared to January and February the debris was drier, and woodlice were more closely associated with the soil-debris interface. Hand-searching within leaf litter and flood debris in the hedgerow drew similar observations with woodlice only being found in patches of moisture and typically at the soil-leaf litter/flood debris interface. An exception was at sample point H2 within the hedgerow where all *H. ripariu*s were found within crevices of a rotten log (20cm diameter) which was partly embedded in the ground. At sample point H5, *H. riparius* were found at a depth of several centimetres in the soil beneath a partly embedded, rotting hawthorn branch. Counting *H. riparius* was difficult because they were fast moving and rapidly disappeared into gaps in the soil surface.

Sample sizes were too low to draw firm conclusions about the relative abundance of the species between habitats but *H. riparius* was the most frequently encountered species being found at nine out of ten sample points. It was also the only species recovered from the refugia (Table 2) with specimens in all five refugia placed in riverside debris piles and one refugium placed in the hedgerow. Seventeen *H. riparius* were found in the refugia which had been wetted compared to a single specimen in the dry refugia. The difference in numbers of *H. riparius* found in damp and dry refugia was statistically significant (Wilcoxon Signed Rank test, $W = 6.00$, $p = 0.031$).

Table 2: Numbers of woodlice found by hand-searching and in dry and wet refugia at five points in riverside debris piles (D1-D5) and northern hedgerow (H1-H5). The presence of flood debris (Y=yes, N=No) and depth of dead plant material is shown for each sample point.

	Flood debris pile					**Hedgerow**				
	D1	**D2**	**D3**	**D4**	**D5**	**H1**	**H2**	**H3**	**H4**	**H5**
Flood debris	Y	Y	Y	Y	Y	Y	N	Y	N	Y
Depth of leaf litter/debris (cm)	20	20	25	15	20	25	3	35	3	35
Hand-search										
H. riparius	1	8	3	1	30	8	6	7	0	8
T. rathkii	0	0	2	0	0	8	0	0	0	0
T. pusillus	0	0	1	25	0	1	0	0	0	0
P. muscorum	0	0	0	0	0	0	1	1	0	0
P. scaber	0	0	0	0	0	2	1	0	0	0
A. vulgare	0	0	0	0	0	1	0	0	0	0
Dry refugia										
H. riparius	0	0	0	0	1	0	0	0	0	0
Damp refugia										
H. riparius	1	1	5	2	2	6	0	0	0	0

Developmental status and sex of *Hyloniscus riparius*

In each month, *H. riparius* individuals recorded during hand-searches included both adults and juveniles, which differed greatly in size. Of the 20 specimens collected from the riverside flood debris on 7th January, 12 were adult females and two were adult males. The remaining six individuals measured < 1mm in length and were considered juveniles. Juveniles from this sample were examined under a laboratory microscope and were assigned to *H. riparius* due to the diagnostic features, including the characteristic antennal flagellum which has a tapered terminal article and the presence of a single ommatidium. Secondary sexual characteristics were not developed, which meant sex determination was not possible. Three additional juveniles were observed in the field had a single ommatidium, viewed using a high magnification hand lens (Opticron x15 magnifier hand lens), and were also recorded as *H. riparius*.

One individual which was collected in January was initially suspected to be gravid based on the appearance of the marsupium and retained for laboratory examination; although no young were present within the marsupium it was confirmed as an adult female due to a rounded projection on the base of the merus.

Specimens recorded during the hand searches were not sexed. Individuals recorded in the hedge refugia and tussocks in January and February included one adult female and three juveniles.

A total of 18 specimens collected from refugia in June were identified under laboratory conditions. There were six adults and six juveniles from flood debris piles, and five adults and one juvenile from the hedgerow. The juveniles had diagnostic features consistent with *H. riparius* but lacked fully developed secondary sexual features (such as hooked projection). One hedgerow specimen was confirmed as a breeding female with young in the marsupium.

Overall, these observations indicate the presence of breeding populations within both the flood debris and the interior of the northern hedgerow.

Discussion

Hyloniscus riparius exhibited a strong association with flood debris (Tables 1 and 2). Exceptions were three individuals found within rush tussocks in the floodplain meadow in January/February and six found within leaf-litter beneath the hedge canopy in June (Tables 1 and 2).

Overall, the results suggest an association between the occurrence of *H. riparius* and microhabitat factors, such as damp, decaying organic matter, rather than broad habitat types. The results are consistent with ecological preferences described in the literature, emphasising the species' association with damp, high organic matter habitats (Berg *et al.*, 2008; Gregory & Farmer, 2023). Observations at LMRM also suggest that flood borne dispersal maybe a significant factor in the distribution of *H. riparius*. An interesting question is whether records of *H. riparius* at LMRM represent dynamic colonies that are maintained by replenishment of individuals carried by regular flooding or represent a permanent population in the floodplain landscape. The meadows flood annually, and deposition of debris is associated with depressions, fence lines and hedgerows that serve to trap floating material in a more-or-less predictable manner. It is therefore unclear whether *H. riparius* observed within flood debris are primarily carried anew with the floating material, colonise the debris from the surrounding habitat, or a combination of both. The present study began immediately after flood waters receded, suggesting that individuals were carried with the debris, however, debris tends to be deposited in the same location each year, hence a definitive conclusion cannot be reached. Larger pieces of debris, such as rotting logs, may be particularly important for both maintaining numbers between floods, and as a source of colonists, since these supported large numbers within debris piles and the hedgerow.

The few records of *H. riparius* from rush tussocks hint at flood borne dispersal being important for the species colonising new habitat. Individuals within tussocks were found in moist conditions at the base of the stems but the tussocks, and grassland in general, lacked a build-up of dead plant material suggesting the floodplain meadow is a 'sink' habitat unable to support a viable population. Records from rush tussocks were distant from the main population in riverside debris piles (Figure 8), suggesting that these individuals were deposited in the recent flooding. A further question that awaits investigation is whether the records at LMRM preface colonisation of the wider countryside away from the River Avon. Observations from Europe, Russia and the United States suggest *H. riparius* may be able to expand its range beyond riparian habitats where suitable microhabitat exists, but that its distribution may be dynamic, with local extinctions and recolonisations, as moisture levels fluctuate in more marginal habitats (Stoyenoff, 2001). To date, *H. riparius* has only been recorded from riparian habitat in the UK (Farmer, 2022; Gregory, 2024a).

Insights into species' habitat requirements can often be obtained via interspecific comparisons, although questions about the relative importance of environmental tolerance and competitive interactions inevitably arise. Comparisons between *H. riparius* and *T. rathkii* are informative. Unlike *T. rathkii, H. riparius* lacks pseudotracheae on the abdominal pleopods. These assist in reducing water loss in terrestrial woodlice (Gregory, 2019, p. 21). Combined with its small size, the absence of pseudotracheae makes *H. riparius* particularly prone to desiccation. This difference may explain the wider distribution of *T. rathkii* across habitats at LMRM (Table 1) with *H. riparius* more dependent on moist conditions beneath accumulations of dead plant material. A greater dependence on moisture may also explain why the abundance of *H. riparius* within piles of flood debris is related to the depth of material (Figure 10), while this was not the case for *T. rathkii*. The ability of *T. rathkii* to tolerate drier conditions and a wider range of riparian microhabitats than *H. riparius* has previously been documented in continental Europe (Farkas & Vilisics, 2008; Šatkauskienė, 2021). The two species may compete, although evidently any interspecific competition is insufficient to cause competitive exclusion since they frequently co-occur throughout their ranges in Europe (Gongalsky *et al.*, 2013; Gregory & Farmer, 2023). Both species have recently colonised LMRM, although *T. rathkii* was first documented two years prior to *H. riparius*. Earlier establishment may have enabled *T. rathkii* to disperse more widely within the floodplain meadow, hence further survey work to monitor these species distributions would be informative.

The abundance and distribution of other woodlouse species recorded across the floodplain meadow are indicative of their generalist habitat preferences (Richmond *et al.*, 2005). Following *H. riparius* and *T. rathkii*, *P. muscorum* was the most widespread species in terms of the range of habitats occupied (Table 1, Figure 9). Species, other than *T. rathkii*, previously recorded with *H. riparius* in 2022 were *T. pusillus* agg, *P. muscorum*, *O. asellus*, and *P. scaber* (Gregory & Farmer, 2023; Gregory, 2024b). In the present study, these species were confirmed as co-occurring with *H. riparius*, while a single *A. vulgare* was also found with *H. riparius* in a refuge trap (Table 2). Comparison of hand-searching and use of refuge traps indicates that hand-searching is more efficient at producing an inventory of species (Table 2). The efficacy of the refugia can be enhanced by wetting the cardboard prior to deployment, although, for reasons unknown, the refugia appeared to less effective when placed within the hedgerow compared to placement within riverside piles of flood debris (Table 2). Deployment of refuge traps may be a useful approach when many sites need to be sampled, and time constraints prevent hand-searching. However, time devoted to construction, placement, collection and subsequent sorting of material must also be factored into the use of refuge traps.

The true extent of *H. riparius* distribution across the UK remains unknown, however it is likely that anthropogenic activity contributes to its dispersal (Gregory *et al.*, 2023). As Gregory *et al.* (2023) highlights, Evesham is known for its market gardening history, with the landscape now home to many glasshouses for food production. The movement of horticultural material from Europe could be a possible route for the arrival of *H. riparius* into the UK with flooding subsequently assisting its dispersal in the region. *Hyloniscus riparius* has been recorded upstream along the River Avon at the Valley Country Park, Evesham (SP049470) (Farmer, 2023), at Gore Meadows (SO98914540) (Farmer, personal communication, 2025) and Haines Meadows, adjacent to LMRM (SO96764705) (Farmer, 2022). The populations at LMRM and Haines Meadows may have originated from the Valley Country Park potentially having been transported downstream with debris during flooding.

Future surveying will help elucidate the origins of the *H. riparius* in the West Midlands and assist in monitoring its potential spread. The species occupies damp stream sides, lakeshores and woodlands in its European range (Gongalsky *et al.*, 2013) so the species may yet be found beyond its current riparian distribution.

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