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New Forest HLS Scheme Specialist Habitat and Species Surveys:

Survey and assessment of Long-spined ant *Temnothorax interruptus* status in the New Forest

Higher Level Stewardship Agreement

The Verderers of the New Forest AG00300016

January 2018

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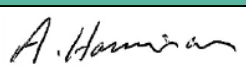
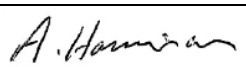
Draft v0.1	31/10/2017	Draft for client review	Elena Cantarello	
Final v1.0	12/01/2018	Final version	Elena Cantarello	

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EXECUTIVE SUMMARY

This report describes the current distribution of Long-spined ant *Temnothorax interruptus* nests and reports on the habitat conditions of the ten sites surveyed, as per the specifications in the contract document. An additional site survey was carried out at Dibden Bottom, as a cursory observation indicated the presence of several ant colonies (Table 1).

- Across the 11 sites, eight sites (73%) were considered to have suitable habitat to support *T. interruptus* populations.
- *T. interruptus* nests were recorded in three sites: Shatterford Bottom (2 nests), Shatterford Bottom, near Denny Wood (1 nest), and Yew Tree Heath (3 nests).
- All quadrats with *T. interruptus* nests had a bare ground cover > 10 %. This percentage was higher compared to null quadrats (absent of *T. interruptus* nests) ($P<0.01$).
- All quadrats with *T. interruptus* nests had a stone/rock cover between 10-15 %. This percentage was higher compared to null quadrats ($P<0.01$).
- All quadrats with *T. interruptus* nests were found to have *Erica cinerea* cover of at least 10 % while only 70 % of null quadrats had some *Erica cinerea* cover. The percentage of *Erica cinerea* cover in the quadrats with *T. interruptus* nests was higher compared to null quadrats ($P<0.05$).
- The mean height of *Erica cinerea* and *Deschampsia flexuosa* cover combined was 10 cm (SD ± 2.8 cm) and all nests were found in lightly grazed areas. *Erica cinerea* cover in the quadrats with *T. interruptus* nests was relatively sparse and generally in the building or established stages; *Deschampsia flexuosa* was found in distinctive, isolated tufts within quadrats with a maximum of 10% cover overall.
- *Calluna vulgaris* cover throughout the transects at Yew Tree Heath and the two sites at Shatterford Bottom, was at the building, established or degenerate stages with a mean percentage cover of 33 % and a mean height of 32 cm (± SD 9 cm). Over 45 % of the *Calluna vulgaris* was at the degenerate stage in all of the *T. interruptus* nest quadrats.
- *Cladonia* spp. was not found in any of the *T. interruptus* nest quadrats.
- Other ant species found across the sites included Formica cunicularia, *Lasius niger*, *Lasius alienus*, *Myrmica scabrinodis*, *Myrmica ruginodis* and *Leptothorax acervorum*. In sites where *T. interruptus* nests were found, all of the other six other ant species were also found to be present. This included nests, foragers and alates (sexual, winged ants).
- Out of the ten sites for which historical records were available, seven showed a decrease in the number of nests recorded and three demonstrated no change.

Table 1. Location of *T. interruptus* nests within the New Forest.

No.	Location	NGR	NBN database	HBIC	Invertebrates of the New Forest	This study, 2017
1	Black Down	SU351065	Records in 1980			Not present
2	Dibden Bottom 1	SU392070	Records in 1980			Not present
3	Dibden Bottom 2[1]	SU392069				Not present
4	Dur Hill Inclosure	SU190010			Records exist – date unknown	Not present
5	Matley Bog	SU335072	Records in 1971			Not present
6	Matley Heath	SU340067		Records in 2002		Not present
7	Matley Passage, near campsite	SU327076		Records in 2007		Not present
8	Matley Passage, west of road	SU332072		Records in 2007		Not present
9	Shatterford Bottom	SU340060	Records in 1970			2 nests found
10	Shatterford Bottom, near Denny Wood	SU336068	Records in 1977			1 nest found
11	Yew Tree Heath	SU370062	Records in 1980			3 nests found

[1] Additional site

CONTENTS

1. INTRODUCTION

The Long-spined ant (*Temnothorax interruptus*) is nationally rare and considered of principal importance for the conservation of biodiversity in England. *T. interruptus* is listed in the S41 Natural Environment and Rural Communities Act (NERC, 2006), which contains 943 species identified as requiring action under the UK Biodiversity Action Plan (BAP). *Temnothorax interruptus*, was previously known as *Leptothorax interruptus* (Bolton, 2003). *T. interruptus* colonises warm, dry, open areas with a sparse cover of low-growing vegetation. Here, it nests under moss, lichen or small flat stones, in or among old heather roots, in peat, or among the roots of fine grass (Collingwood, 1979, Børgesen, 2000).

Records for the New Forest are centred around Matley bog, Shatterford bottom area, with an odd record near Durhill, and refer to dry heathland where it is stated to prefer grazed areas or burned areas with less than 10 years heather generation (Falk, 1991). The surveys for this project cover all 10 sites known to have historical records, plus one additional site which looked suitable after a cursory examination.

1.1 Aims and objectives

The aim of this project was to survey all historically known long-spined ant sites within the New Forest. In addition to mapping the location of individual ant nests, the specific objectives were:

- To assess habitat characteristics, vegetation cover, height, structure and water saturation at each survey site.
- To indicate where the species was present and absent during the field survey.
- To elucidate the habitat variables which determine suitability for *T. interruptus.*
- To provide notes on competing species.
- To provide an assessment of the current status of the population within the New Forest.
- To provide an analysis of historic trends by assessing potential change in distribution and population size within the New Forest.
- To discuss the threats and risks to the populations around the New Forest.

2. METHODOLOGY

2.1 Field methods

The surveys for this project were undertaken on foot from the nearest car park or suitable forest road, according to the recognised invertebrate survey methods and protocols, as appropriate (JNCC, 2004, Drake et al., 2007). The survey was undertaken from June to August 2017 and was dependant on weather conditions and seasonal variations during a rather wet and cold July and August. Literature (e.g. Børgesen, 2000) suggests that surveys should take place in weather conditions that are likely to encourage the ants to bring brood up above ground as this evidence is required to determine where nests are present. Accordingly, surveys were carried out on days when the air temperature was at a minimum of 14°C.

Roots of *Ericaceae* plants, bryophytes and grasses on heathland and bare sand were examined to look for signs of the presence of ant nests. A search was also made under stones and dry wood and within patches of plant debris for nest entrances.

To assess the current distribution and population trend of *T. interruptus*, a preliminary survey of each of the 10 study sites was undertaken to determine the dry, open locations with a sparse cover of low-growing vegetation most likely to contain ant nests. Four transects, each 50 m long, were set up from a central point running north to south and from east to west. From the central point, the entire transect line was searched (including areas under stones/dead wood and between roots) within an area of 1 m either side of the transect line (i.e. 100 x 1 m² plots per transect) for *T. interruptus'* nests/activity and each nest found was recorded with a GPS (Garmin 60CSx).

Plant structure and general plant composition was assessed every 2 m² along each of the 4 transects, totalling twenty-five 2 m² plots per transect. One additional site, where the terrain looked favourable, was added to the survey, giving a total of 11 sites.

Each site was given a water saturation rating from 0-2 using the criteria below (Table 2.1).

Table 2.1. Water saturation ratings used to assess sites characteristics.

Water saturation rating	Description of criteria
0	Ground was completely dry underfoot even when pressure was applied.
1	Ground was superficially dry but became wet underfoot when pressure applied.
2	Standing water of at least 2 cm was apparent without pressure being applied.

A detailed plant survey was carried out in every plot where *T. interruptus*' nests were found. This included records of grazing activity, in addition to vascular/nonvascular plant percentage cover and height. Five random null plots - where there was no evidence of ants – were surveyed in each of the four transects in the same detailed way. As nests are frequently grouped together (Lach et al., 2010), this method was adopted to ensure complete coverage. Nest presence and number was determined

by gentle, non-invasive moving of soil surrounding the roots of heather and under stones and dead wood with a hand-held garden fork to ascertain where solaria were present. When *T. interruptus*' nests were located, the nest was swiftly closed up and material replaced to minimise damage to the nest and vegetation.

Records were taken of where the species was present and absent during the field survey, including notes on competing species, where present, near colonies. The size of each population was estimated and the current status of the population of *T. interruptus* within the New Forest assessed. Historic trends were analysed by assessing potential change in distribution and population size within the New Forest, including a comparison of New Forest sites recorded in literature.

Finally, factors that might impact on the viability of species (i.e. threats and risks) are presented for each site, with recommendations on habitat management, whilst taking into account the multi species management approach used in the New Forest. For those sites where *T. interruptus* was not present, the suitability of the habitat on those sites is described and possible reasons for the absence of the species identified.

2.2 Ant Identification

The following characteristics were used to identify *T. interruptus* and other ant species close to *T. interruptus'* nests.

T. interruptus (Bolton, 2003) are small in size, between 2.2-3.4 mm (Børgesen, 2000) and vary from light yellow to brown amber in colour. They can be identified by their tracheal air sacks which appear as white spots within the first gaster segment. The distal edge of this segment also has a grey band which is interrupted in the middle giving the species its name (Børgesen, 2000). The frontal area from the mouth to the eyes is also pigmented featuring a band which varies in colour and width between colony members (Skinner and Allen, 1996). The last three segments at the tip of the antenna are the same length as the rest of the funiculus and form a dark club at the end. The upper surfaces of the head and thorax have a sculptured effect and the propodeum spines are long and curved with no projection below the postpetiole segment (Skinner and Allen, 1996, Barnard, 2011).

Formica cunicularia (Latrielle, 1798) can be distinguished from other Formica species found in heathland areas, by the reddish areas found on the thorax, by the dull matt frontal triangle and the absence of erect hairs on the pronotum. The species are abundant on coastal sites, downland areas and heathlands where they nest under stones or under bare ground particularly in south-facing slopes (Pontin, 2005). Brian (1977) notes that this species is also known to build small mounds 10-30 cm in diameter.

The formicine black ant, *Lasius niger* (Linnaeus 1758) can be found within a diverse range of habitats including urban parks, heathlands, roadside verges, gardens and grasslands (Brian, 1977, Thiel and Köhler, 2016). The species is small (workers < 7 mm in length), dark matt in colour with a single waist segment and can be identified, with the use of a microscope, by the short, soft, standing hairs found on the antenna and hind tibia and by the dense pubescence seen on the clypeus (Royal Entomological Society 1975). It can be distinguished from other dark coloured ants by the relatively short legs and segments 2-5 of the funiculus which are shorter in length than the total of the other funicular segments. *Lasius niger* can be distinguished from the similar, *Lasius alienus*, by the presence of standing hairs on the scape of the antenna and hind tibia.

Open areas with patchy plant cover are typically chosen for nesting (Haatanen et al., 2015). While *L. niger* will occasionally build soil mound nests (Environment Agency, 1998) and have been found to inhabit disused *Formica candida* cone nests in boggy heathland terrain (Rees, 2006), nesting sites are primarily located under flat stones in moist soil where a series of underground tunnels, close to the surface, are constructed in the nesting vicinity (Brian, 1977). Stone crevice nests have the benefit of providing protection against trampling while simultaneously absorbing radiation and creating an equable microclimate. Tunnels are frequently multi-branched and will be covered in a soil 'canopy' if they break through the soil's surface.

The formicine brown ant, *Lasius alienus* (Foerster 1850) is also widespread within the UK; Brian (1977) defines *Lasius alienus* as primarily a heathland species preferring the warmer, dry heathland areas where nest construction takes place in shallow, subsurface soil where a series of galleries and shafts are constructed. Foraging takes place underground, especially in the presence of interspecific competition from *Lasius niger* who are potentially able to suppress the territory range of smaller, competing species (Sommer and Hölldobler, 1995). *Lasius alienus* can be distinguished from *Lasius niger* by its slightly small size (< 6 mm) and by the absence of standing hairs on the scape of the antenna and hind tibia (Skinner and Allen, 1996).

Myrmicinae ants are easily identified by their double-waist segment consisting of the petiole and postpetiole (Skinner and Allen, 1996). The species are generally small (< 7 mm), a uniform red/brown in colour and have 12 antennal segments with no outgrowth or flange separating the antennal scape from the funiculus. Myrmicinae mandibles have teeth while the propodeum has a set of spines and the petiole upper surface is held at a sharp angle to the hind face (Royal Entomological Society 1975).

Myrmica scabrinodis (Nylander 1846) is a widespread and common ant in the UK which inhabits a range of habitats including bogs and moorland, humid heathland, grasslands, forests and open woodland (Radchenko and Elmes, 2010). Nests can be built in the soil or under bark and in very boggy heathland areas, can be established in dense *Sphagnum* clusters especially where they rise above ground water levels (Boyce, 2003). *Myrmica scabrinodis* also build solaria, constructed from vegetation and chewed earth fragments to incubate their brood during the summer months (Boyce, 2003). Brian (1977) suggests that *Myrmica scabrinodis* can potentially live in hotter, more arid habitats than other *Myrmica* species as their nest construction features thick, mud-filled walls which retain moisture. Workers are kept on the surface of the soil throughout the year (although inactive when the temperature falls below 8°C) giving the species a territorial advantage during the spring (Brian, 1977).

Myrmica ruginodis (Nylander 1846) can be distinguished from *Myrmica scabrinodis* by the former's long propodeum spines which have the same measurement in length as the distance between the tips (Skinner and Allen, 1996). *Myrmica ruginodis* is a common and widespread species in the UK able to inhabit cooler habitats than other *Myrmica* species (Radchenko and Elmes, 2010) hence it can be found in forests, woodland clearings, mires, humid heathland and grasslands. Nests are frequently constructed under bark and rotten wood in forests but in grasslands, a shallow soil nest is built (Radchenko and Elmes, 2010). In boggy areas, particularly, solarium soil structures are built over mossy nests for brood development. Brian (1977) considers these ants to be a nomadic species moving regularly to colonise new habitats. For this reason, he claims that their nests are far less

robust than those created by *Myrmica scabrinodis* being more lightly built with thinner walls. They do however build deep underground chambers for overwintering.

Leptothorax acervorum (Fabricius 1793) is a small, yellow-brown, widely distributed Myrmicine ant, which nests in tree stumps and under bark in the UK, can be distinguished from other Myrmicine species by the distinctive 11 segmented antennae found in the worker ants which tend to forage alone (Skinner and Allen, 1996). Brian (1977) notes that although the species is widely distributed, colonies tend to occur in patches - often under hard wood where small entrance holes are made through which other ants cannot pass or under the soil crust where the species lives in polygynous (multi-queened) colonies.

In a few cases where it was not possible to identify the species in the field, ant samples (except from *T. interruptus*) were collected and examined using a Brunel SP28 Universal microscope with an additional focused LED light source and x5, x10 and x20 long-working distance objectives for use without stain or oil slide preparation. Specimens were identified using entomological keys from the Royal Entomological Society (1975), Skinner and Allen (1996) and Barnard (2011), and verified with reference to a collection of heathland ant specimens identified in 2016 by entomologist Andy Abbot (Abbot Ecology, Environmental Consultants, Wareham, Dorset).

3. RESULTS

3.1 Survey site results

The following sections 3.1.1 to 3.1.11 provide site summaries; including the status of ant communities, a description of vegetation cover/structure and recommendations for future management. A comparison of New Forest sites where *T. interruptus* has been previously recorded is also included for historical context. Where National Grid Reference (NGR) coordinates are provided, these refer to the central point located in the driest part of the site where the four transects meet.

3.1.1 Black Down

NGR: SU3514706566

***T. interruptus* not found; site suitable**

Site description

Black Down is situated to the north east of Beaulieu Road Station, to the east of Denny Wood and to the south west of Decoy Pond Farm. The site is a dry heathland area with a water saturation rating of 0. It is dominated, for the most part, by *Calluna vulgaris* and *Molinia caerulea,* except on the western side which culminates in an area of short grassland (Figure 3.1) leading into *Pinus sylvestris, Ilex aquifolium and Betula pendula* woodland.

The eastern and northern transects lead to worn grass tracks and the site was heavily grazed by ponies and cattle; the mean height of the vegetation across the four 50 m transects was 13.5 cm (± SD 3.5 cm).

Figure 3.1. Central point at Black Down.

Figure 3.2 shows the percentage of vegetation and ground cover across 17 categories on the site, which featured the occasional cluster of *Erica cinerea*, frequent bryophyte cover throughout, with clumps of *Ulex minor* on the southern transect.

Two *Myrmica scabrinodis* nests were found here within the bryophyte cushions but *T. interruptus* was not found; although the site was considered suitable.

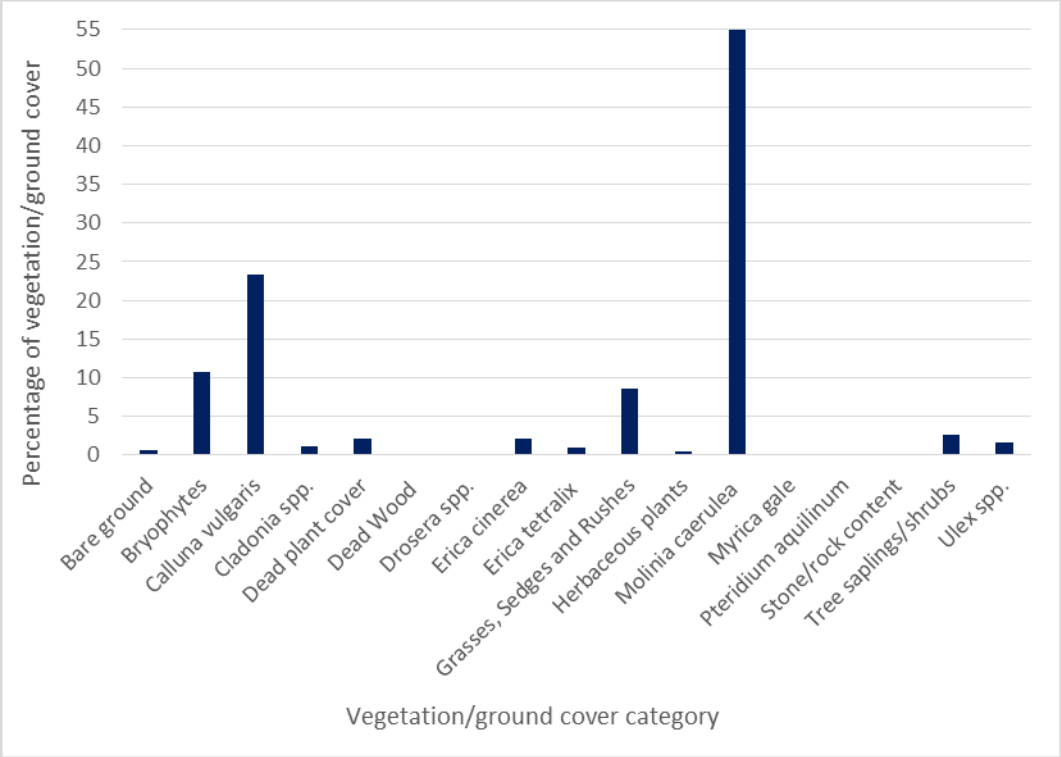

Figure 3.2. Vegetation and ground percentage cover at Black Down.

3.1.2 Dibden Bottom 1

NGR: SU3921606997

***T. interruptus* not found; site unsuitable**

Site Description

Dibden Bottom (Figure 3.3) is an area of humid heathland situated between Marchwood Inclosure to the north and Beaulieu Heath to the south, while the Beaulieu River, which runs along the western side of Dibden Bottom, has several streams flowing into the site. The four 50 m transects, which ran north to south and east to west through a central point on the driest part of the site, were carried out directly to the south of a stream and two circular lines of deciduous trees which curve around Dibden Bottom from the southwest. The site was given a water saturation rating of 0-2; the southern transect was very dry and dominated by *Calluna vulgaris* and *Cladonia* spp., whereas the northern, western and eastern arms were wet underfoot with pools of standing water in places. There was heavy rain on several days directly before the survey, however. There was evidence of cattle and pony grazing and the mean height of vegetation across the transects was 15.6 cm (± SD 3.1 cm).

Figure 3.3. Dibden Bottom 1.

Figure 3.4 shows the percentage cover of vegetation and ground cover within 17 categories. The site was dominated by short *Molinia caerulea*, *Erica tetralix* and *Calluna vulgaris,* with consistent bryophyte cover throughout. The wetter areas on the northern and western transects had pockets of short *Myrica gale* but no *Sphagna* was noted. There was very little dead wood or stone cover but small areas of bare ground could be seen where the *Calluna vulgaris* had become degenerate; dead plant cover (mostly *Calluna vulgaris*) made up 10% of ground cover. No ants were found at this site. The site was considered to be unsuitable for *T. interruptus* inhabitation, as all of the 50 m transects were too wet for the Long-spined ant, except for the southern transect which was too dense in vegetation cover and did not, therefore, provide a suitably warm microclimate.

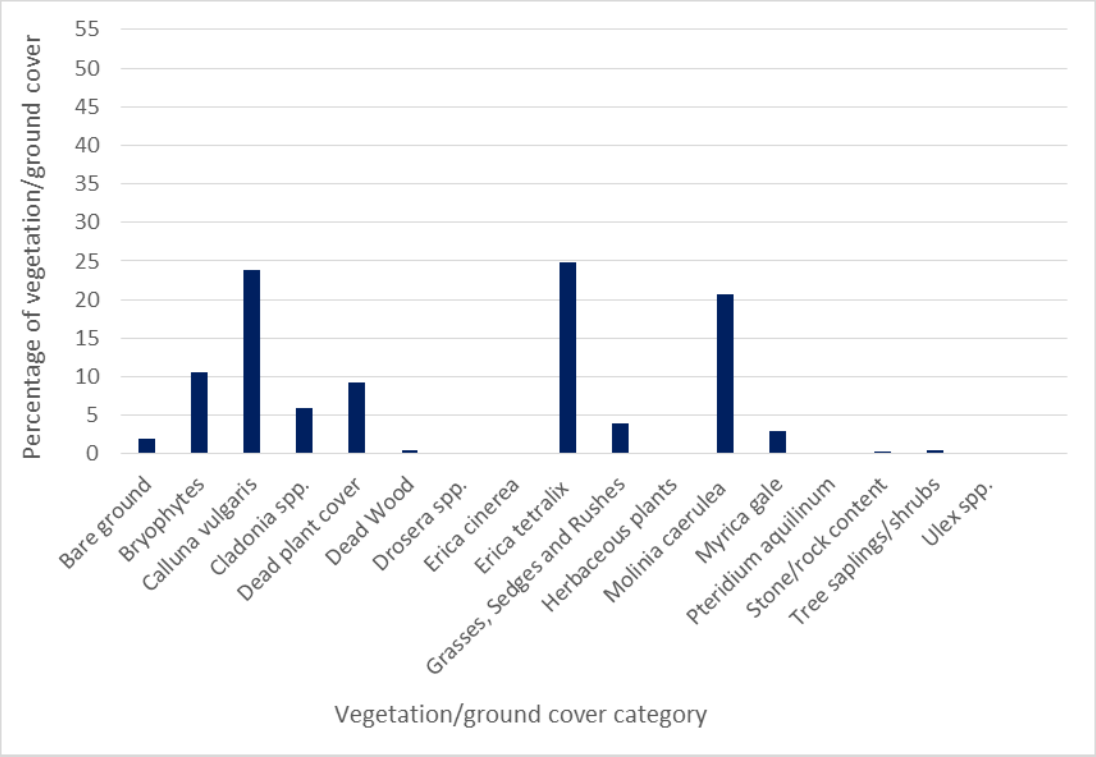

Figure 3.4. Vegetation and ground percentage cover at Dibden Bottom 1.

3.1.3 Dibden Bottom 2

NGR: SU3917107229

***T. interruptus* not found; site suitable**

Site Description

This was an additional site survey carried out at Dibden Bottom (Figure 3.5). The site was chosen as a cursory observation indicated the presence of several ant colonies.

The four 50 m transects, which ran north to south and east to west through a central point on the driest part of the site, were carried out on the northern side of a stream and two circular lines of deciduous trees which curve around Dibden Bottom from the southwest separating the damp heath from the wetter heathland beyond at the bottom of the mire. The site was given a water saturation rating of 0-2; the northern transect was dry while, on the other transects, moisture seeped through the superficially cracked and dry surface of the soil once pressure was applied. There was evidence of cattle and pony grazing on the site and the mean height of vegetation across the transects was 15.57 cm (± SD 3.15 cm).

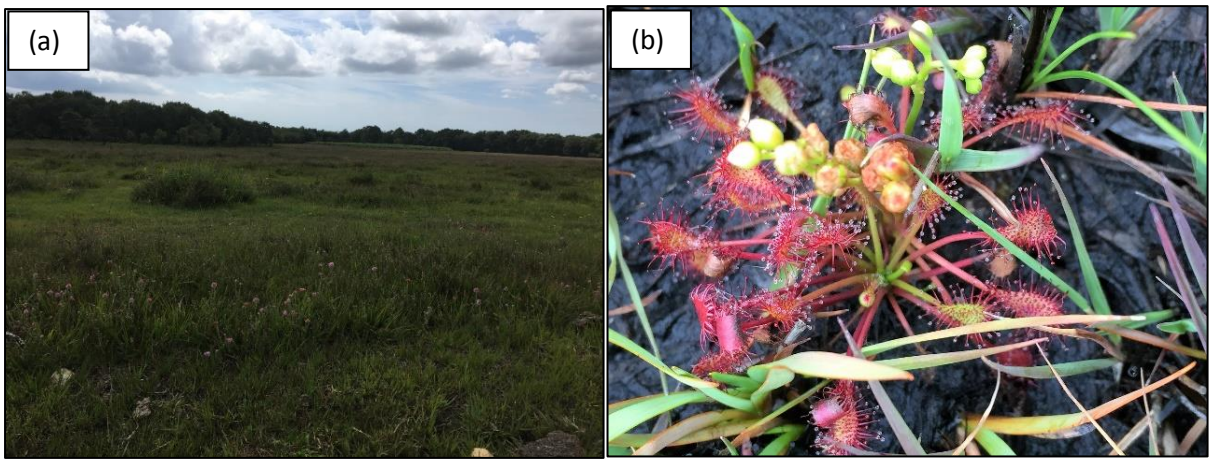

Figure 3.5. Dibden Bottom 2 (a) and *Drosera intermedia* growing in pockets (b).

The site was dominated by extensive cover of short *Molinia caerulea* with *Erica tetralix* and *Calluna vulgaris,* interspersed with clusters of *Carex echinata*, the occasional pocket of *Drosera intermedia* and some bryophyte and *Cladonia* spp. cover. Figure 3.6 shows the percentage cover of vegetation and ground cover within 17 categories. Patches of bare ground were apparent, with minimal stone and dead vegetation cover (both < 5%). *Lasius niger* nests were found under the crusty soil surface and within cattle dung in 15 locations (primarily on the northern transect). *Formica cunicularia* foragers were found within the grassy edge of the heathland on the northern side. Several *Leptothorax acervorum* foragers were found on the grass edge close to the tree line.

T. interruptus was not found at this site; although, the terrain on the northern transect was considered suitable. One *Macrothylacia rubi (*Fox moth) caterpillar was discovered at the base of a *Calluna vulgaris* plant at SU39175 07250.

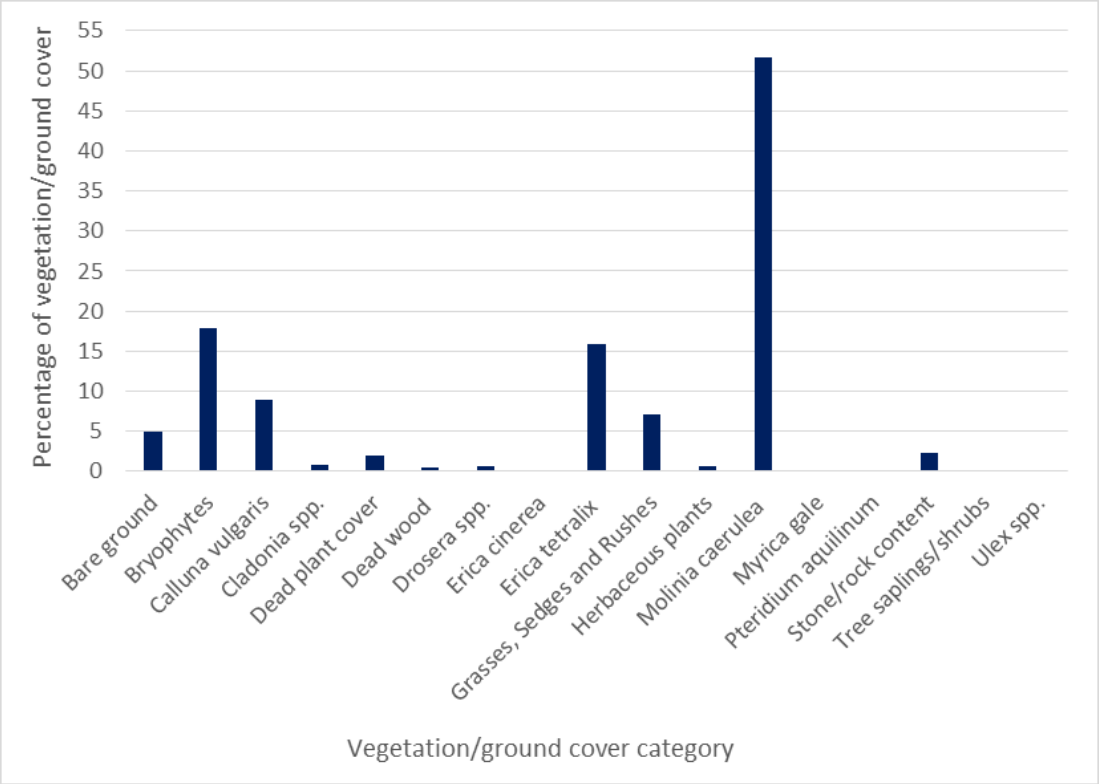

Figure 3.6. Vegetation and ground percentage cover at Dibden Bottom 2.

3.1.4 Dur Hill Inclosure

NGR: SU1928601051

***T. interruptus* not found; site unsuitable**

Site description

This dry heathland site is situated on the southwest edge of Dur Hill Inclosure at Dur Hill Down. The area is bordered by Scots pine forest to the north, south and east while the western side is adjacent to Lugden Bottom (Figure 3.7). The soil was dry (given a water saturation rating of 0) and sandy in composition with occasional tree stumps and some stone cover. The mean height of vegetation at the site was 14.6 cm (± SD 5.1 cm).

Figure 3.7. Heathland at Dur Hill Inclosure.

Figure 3.8 shows the percentage of vegetation and ground cover at the site across the 17 categories which was dominated by dense cover of *Calluna vulgaris*, at all stages of growth, with short *Molinia caerulea*, pockets of *Agrostis curtsii* and occasional stands of *Erica cinerea. Betula pendula* and *Pinus sylvestris* saplings were found frequently on the southern and northern transects, while the western transect ran to a grass track which weaved through the inclosure. The eastern transect had the highest percentage cover of dead wood and featured several rotted tree stumps. There were some signs of grazing by cattle on the western side. No ants were found at this site which was considered to be too densely covered by *Ericaceae* for *T. interruptus* habitation.

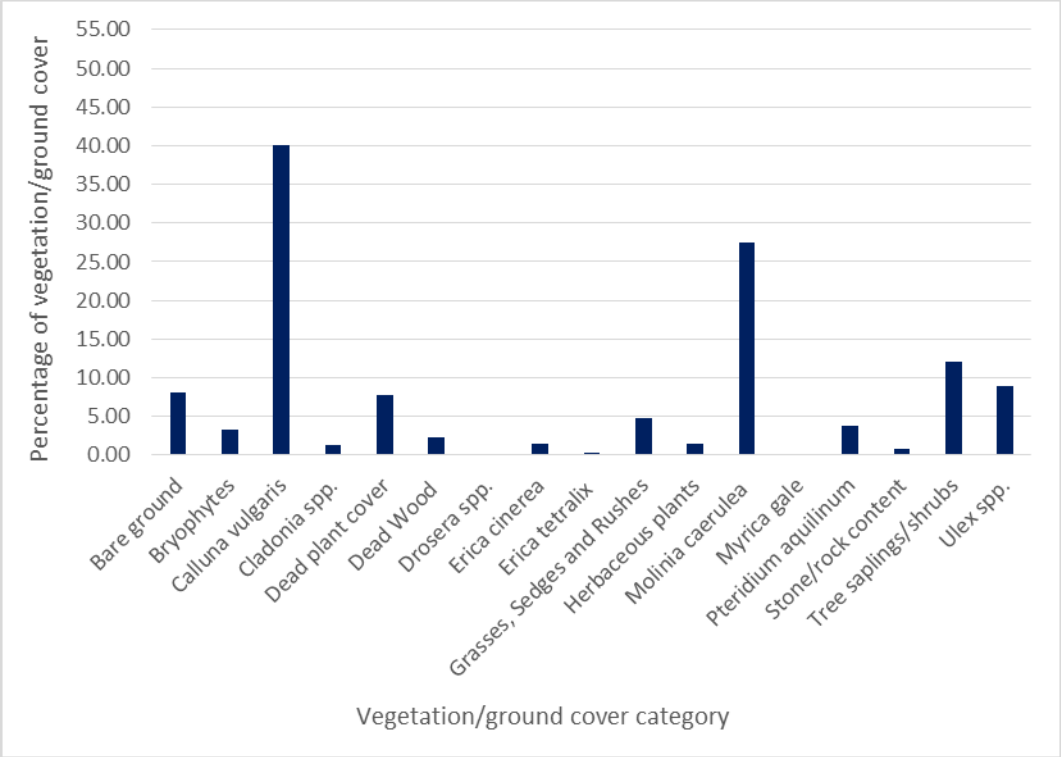

Figure 3.8. Vegetation and ground percentage cover at Dur Hill Inclosure.

3.1.5 Matley Bog

NGR: SU3331807428

***T. interruptus* not found; site suitable**

Site description

This humid heathland site is situated on the northern side of Matley Passage, to the east of Matley car park (Figure 3.9). The transect ran uphill, on the northern transect, to a bank of *Calluna vulgaris* culminating in a dense thicket of *Pteridium aquilinum* and birch woodland which lead to the campsite, while the southern transect ran downhill towards a line of trees.

The water saturation rating given was 0-1; the northern transect was located on dry heathland with stony, sandy soil, while the southern transect quickly became wet underfoot when pressure was applied.

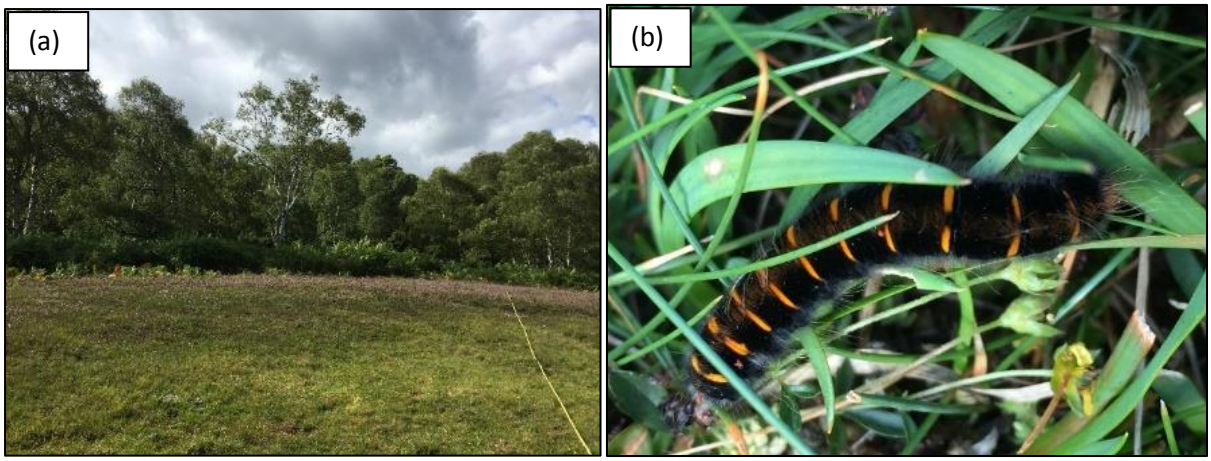

Figure 3.9. The vegetation at Matley Bog (a) and *Macrothylacia rubi* (Fox moth) caterpillar at the base of grasses (b).

Figure 3.10 shows the percentage of vegetation and ground cover on the site which was dominated by *Molinia caerulea* interspersed with pockets of *Carex demissa*, *Sphagnum* and the occasional *Drosera intermedia* in all areas except the northern side, which had predominantly *Calluna vulgaris* cover. The mean height of the vegetation was 16.5 cm (± SD 10.1 cm) and there was evidence of cattle and pony grazing. Five *Myrmica scabrinodis'* nests were found within the *Sphagnum*; three of the nests contained brood. *T. interruptus* was not found at this site; although, it was considered to be suitable.

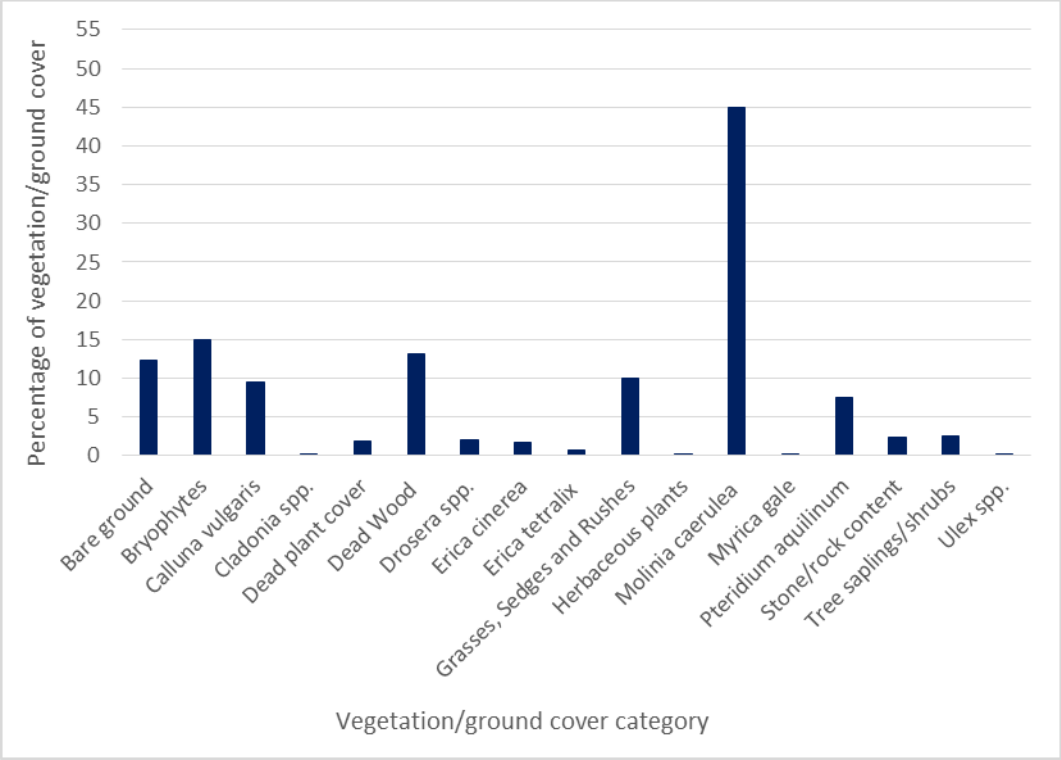

Figure 3.10. Vegetation and ground percentage cover at Matley Passage.

3.1.6 Matley Heath

NGR: SU3400206797

***T. interruptus* not found; site suitable**

Site description

This humid heathland site is situated north of Shatterford Bottom, to the east of Denny Bog and Denny Wood Campsite and to the south of the Beaulieu Road (Figure 3.11). The water saturation rating given for the site was 0 - 2; the heath ranged from dry, sandy areas near the central grid reference to areas of standing water pooling in shallow ditches with the occasional *Drosera intermedia* patch. Much of the heathland was wet underfoot, once pressure was applied, which could be attributed to heavy rainfall in July.

Figure 3.11. dominance of *Calluna vulgaris* at Matley Heath.

Figure 3.12 shows the percentage of vegetation and ground cover on the site which was dominated by dense *Calluna vulgaris* at all stages of development, including the degenerate phase providing woody cover and additional patches of bare ground. Short *Molinia caerulea* was well-represented at 27% and bryophytes and *Cladonia* spp. were found consistently across the site in small clusters. The mean height of vegetation was 15.4 cm (± SD 2.6 cm). There was evidence of cattle grazing on all

transects except the western transect, which became much boggier underfoot at the end towards the tree line. Several decaying tree stumps were recorded on the southern transect close to the centre.

Two *Lasius alienus'* nests were found under dead *Calluna vulgaris* fragments but no *T. interruptus'* nests were located; although, the site was suitable in areas where the *Calluna vulgaris* was degenerate and bare ground was exposed to the sun.

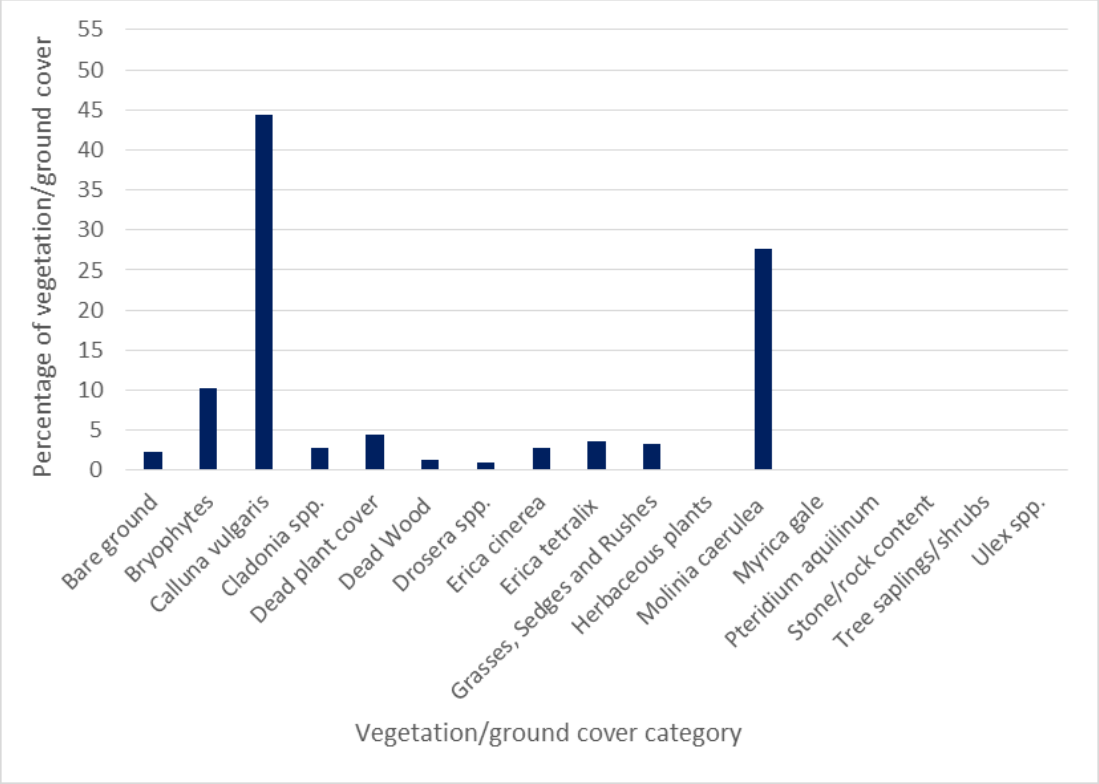

Figure 3.12. Vegetation and ground percentage cover at Matley Heath.

3.1.7 Matley Passage, near campsite

NGR: SU3279207498

***T. interruptus* not found, site suitable**

Site Description

This dry heathland site is situated to the west of Matley campsite, north of the B3056 Beaulieu Road and to the north of Matley Ridge. The site is criss-crossed by sandy tracks which lead to the campsite and dense woodland flanks the southern and eastern sides (see Figure 3.13).

The mean height of vegetation at the site was 15.8 cm (± SD 35.6 cm). The water saturation rating given was 0 throughout the site.

Figure 3.13. Abundance of *Calluna vulgaris* at Matley campsite.

Figure 3.14 shows the percentage of vegetation and ground cover at Matley campsite. Short *Molinia caerulea*, with other grazed grasses such as *Agrostis curtisii* and pockets of herbaceous plants, dominated tracks within the heath, while *Calluna vulgaris*, *Ulex europeaus* and *Pteridium aquilinum* were abundant throughout the central areas of the transect. There were patches of bare ground amongst the more mature *Calluna vulgaris* cover and bryophyte and *Cladonia* spp. could be seen on all four transects. *Betula pendula* and *Pinus sylvestris* saplings were seen occasionally but all were less than 10 cm in height.

No ants were found at this site which was considered suitable for *T. interruptus* habitation.

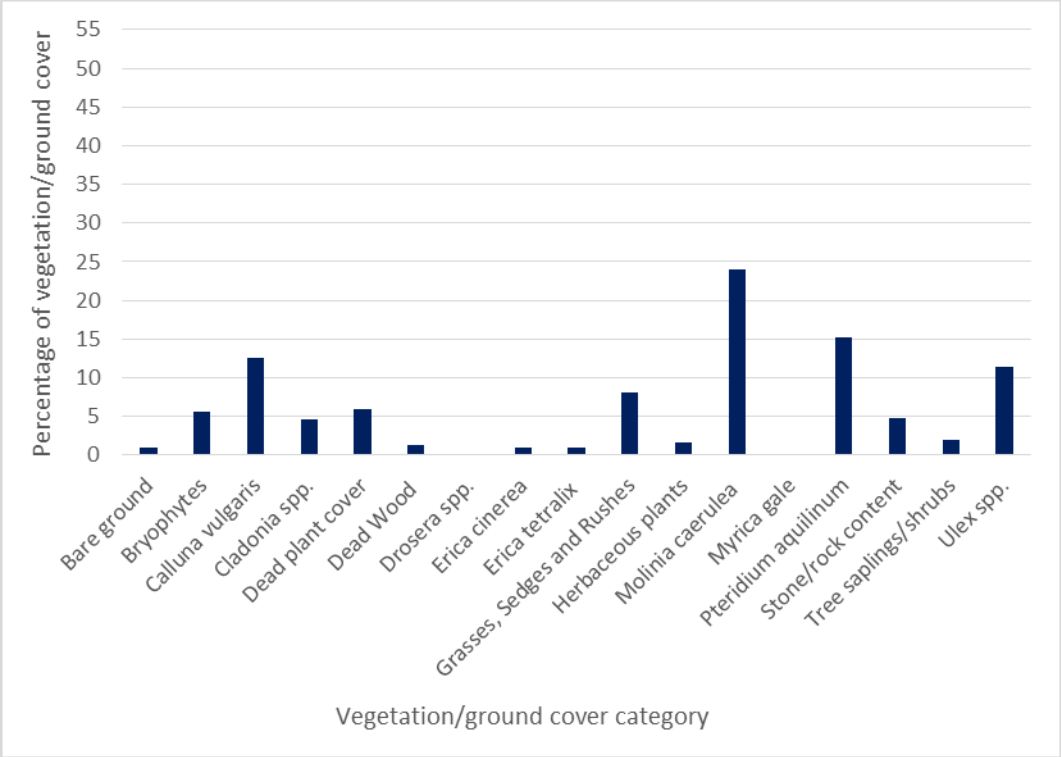

Figure 3.14. Vegetation and ground percentage cover at Matley Campsite.

3.1.8 Matley Passage, west of road

NGR: SU3312007213

***T. interruptus* not found; site unsuitable**

Site description

This humid heathland area is situated between dense woodland surrounding Matley Bog, Matley Heath and Matley Ridge (Figure 3.15). The site was predominantly dry except on the southern side which lead to a stream and areas of scrub, where the ground became boggier underfoot. The site was given a water saturation rating of 1.

The mean height of vegetation at the site was 19.4 cm (± SD 24.6 cm). There was extensive evidence of grazing by cattle, ponies and deer. Taller vegetation, specifically small clumps of *Juncus acutifloris,* could be seen closer to the stream and scrub areas.

Figure 3.15. Humid heathland at Matley Passage.

Figure 3.16 shows the percentage of vegetation and ground cover on the site which was dominated by *Calluna vulgaris* in all stages of development, except for the area close to the stream where *Myrica gale* and tussocky *Molinia caerulea* became abundant. Bryophyte cover (mainly *Sphagnum* which was often dried) was evident on all transects but dominated particularly on the southern side. *Ulex minor* and *Betula pendula* scrub were beginning to encroach at the edges of the site.

No ants were found at this site which was considered to be too dense in *Ericaceae* cover for *T. interruptus* inhabitation.

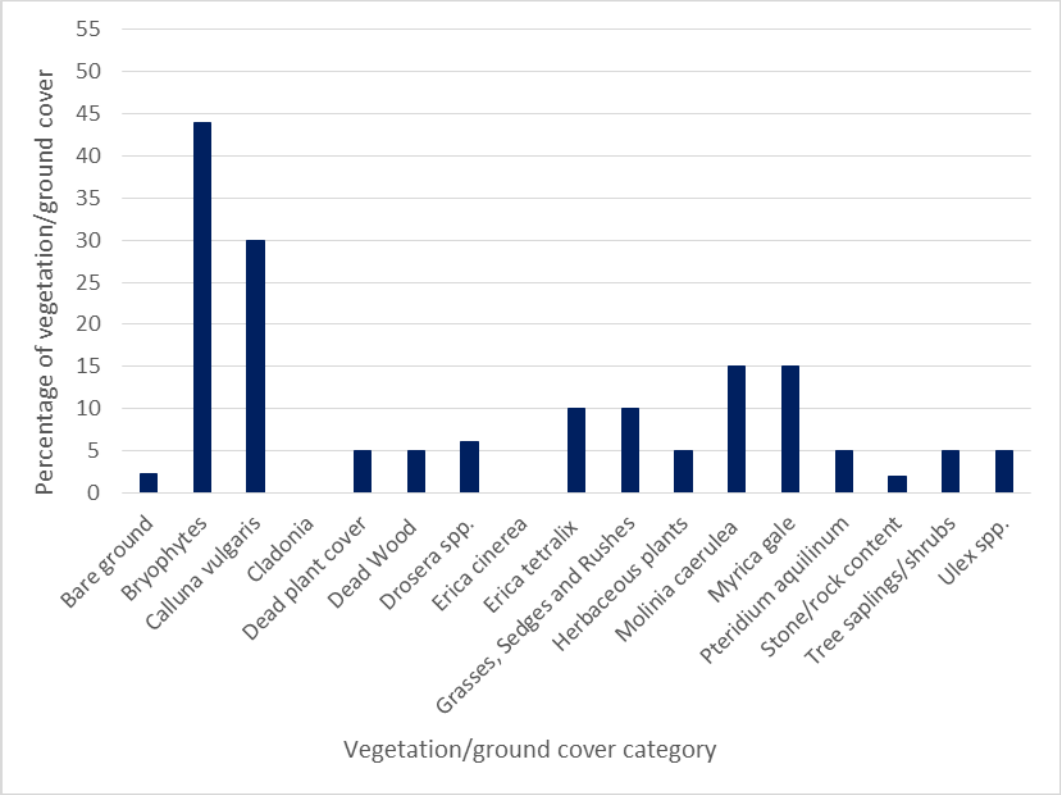

Figure 3.16. Vegetation and ground percentage cover at Matley Passage.

3.1.9 Shatterford Bottom

NGR: SU3409306054

***T. interruptus* found; site suitable**

Site Description

Shatterford Bottom is situated between the large forest areas of Denny Wood and Denny Inclosure to the west, Beaulieu Road Station to the east and Matley Holms to the north. The transect was carried out in a relatively dry, heathland area close to the bottom of the valley, north of Denny Wood and a dense border of *Pteridium aquilinum* which separated the transect site from the woodland beyond. The water saturation rating given was between 0-1; the soil was superficially dry but became damp when pressure was applied for a short period of time.

The mean height of the vegetation across the transects was 21.42 cm (± SD 4.5 cm); the mean elevated by the banks of *Pteridium aquilinum* which fringed the site on the western side contrasting with the *Molinia caerulea* and relatively short *Calluna vulgaris* cover on the other transects. Figure 3.17 shows evidence of grazing by ponies; additional signs of grazing cattle, deer and rabbits were shown through the presence of dung, cropped grass and worn runs which zigzagged throughout the site.

Figure 3.17. Grazing at Shatterford Bottom.

Figure 3.18 shows the percentage cover of vegetation and ground cover at the site. The area was dominated by short *Molinia caerulea* grass with *Calluna vulgaris* in all stages of development, consistent bryophyte cover, banks of *Pteridium aquilinum* interspersed with small clusters *of Erica cinerea* and sparse patches of *Erica tetralix*. There was some bare ground within all four 50 m transects and the ground was frequently covered with dead plant material (mostly *Calluna vulgaris*); although, there were few stones or dead wood.

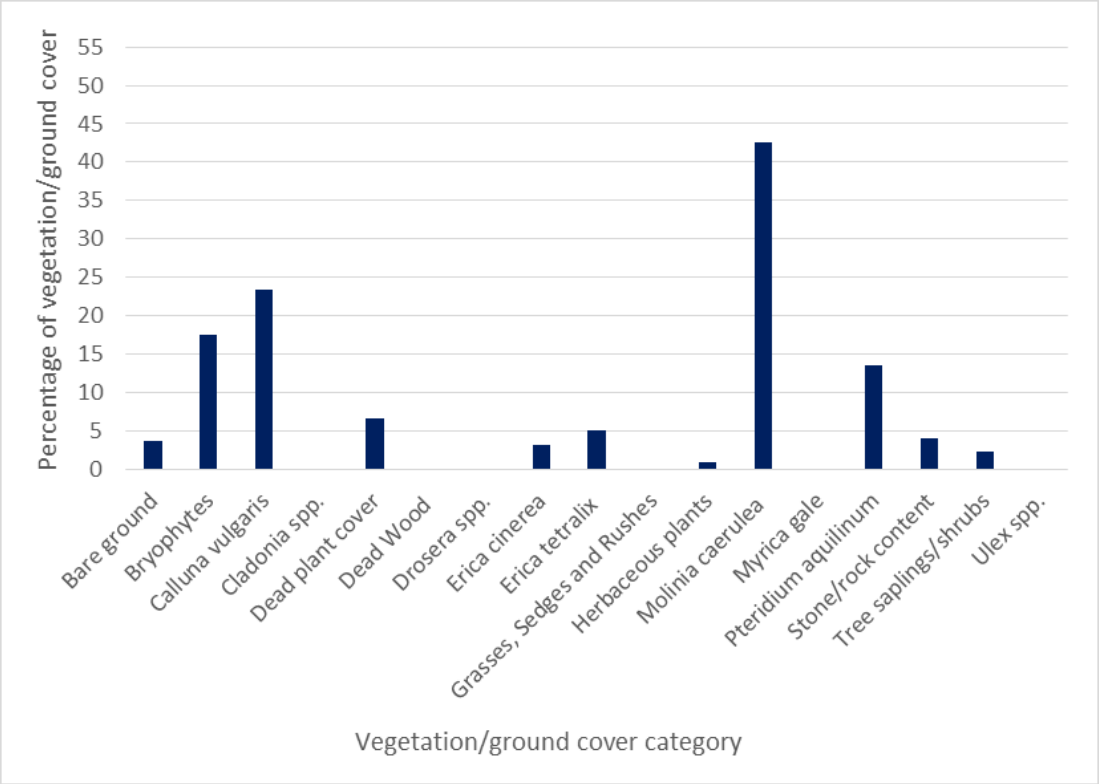

Figure 3.18. Vegetation and ground percentage cover at Shatterford Bottom.

A winged *Lasius niger* alate was seen on the eastern transect and four *Myrmica scabrinodis'* nests were found within the bryophyte cushions. *T. interruptus'* nests were found in two places; one on the northern and one on the southern transects. Both were at the base of sparse, building *Erica cinerea* plants which did not exceed 10 cm in height. Although both 1 m² quadrats were found to contain at least 30 % *Calluna vulgaris*, 40 % was at a degenerate stage, it was contained in distinct pockets and did not exceed 20 cm in height. Figure 3.19 shows the percentage of ground cover found within a 1 m² quadrat around the *T. interruptus'* nests, which had a mean height of 9 cm (± 3 cm).

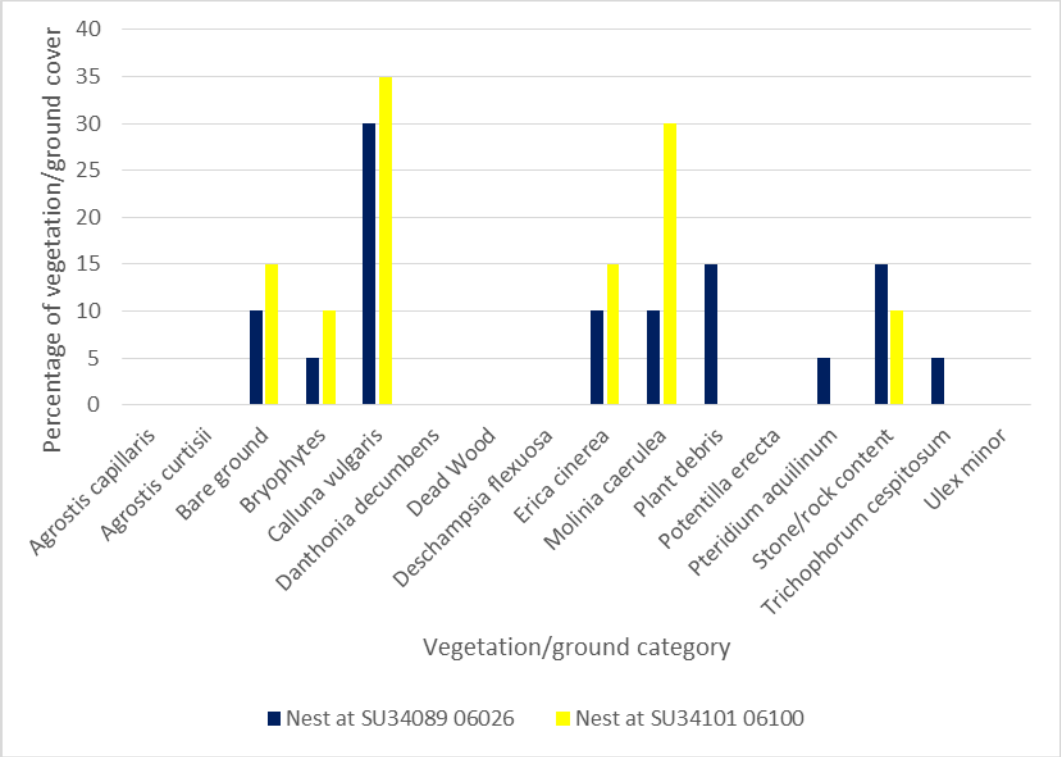

Figure 3.19. Percentage cover of each species within 1 m^2 of a *T. interruptus'* nest.

3.1.10 Shatterford Bottom, near Denny Wood

NGR: SU3360006824

***T. interruptus* found; site suitable**

Site Description

This dry heathland site to the north west of Shatterford Bottom is bordered to the west by Denny Wood and Denny Campsite and to the north by Matley Bog. Figure 3.20 depicts the western 50 m transect and the dense cover of *Calluna vulgaris* mingled with *Erica cinerea*. The water saturation rating given was between 0-1. The mean height of vegetation at the site was 17 cm (± SD 5.3 cm). All four 50 m transects showed some evidence of grazing by ponies and cattle; however, on the southern transect, grazing was very slight.

Figure 3.20. Shatterford Bottom near Denny Wood (a) and *Calluna vulgaris* and *Erica cinerea* cover at the site (b).

Figure 3.21 shows the percentage of vegetation and ground cover at the site across 17 categories. The site was dominated by short, flowering *Calluna vulgaris* interspersed with *Erica cinerea* and rarely *Erica tetralix,* amidst frequent cover of short *Molinia caerulea* grass and occasional patches of bare ground. *Calluna vulgaris* cover on the southern arm was denser, less well-grazed and at a more mature stage of growth, while the damper ditches which crossed the northern arm and ran uphill to the campsite had *Erica tetralix* pockets.

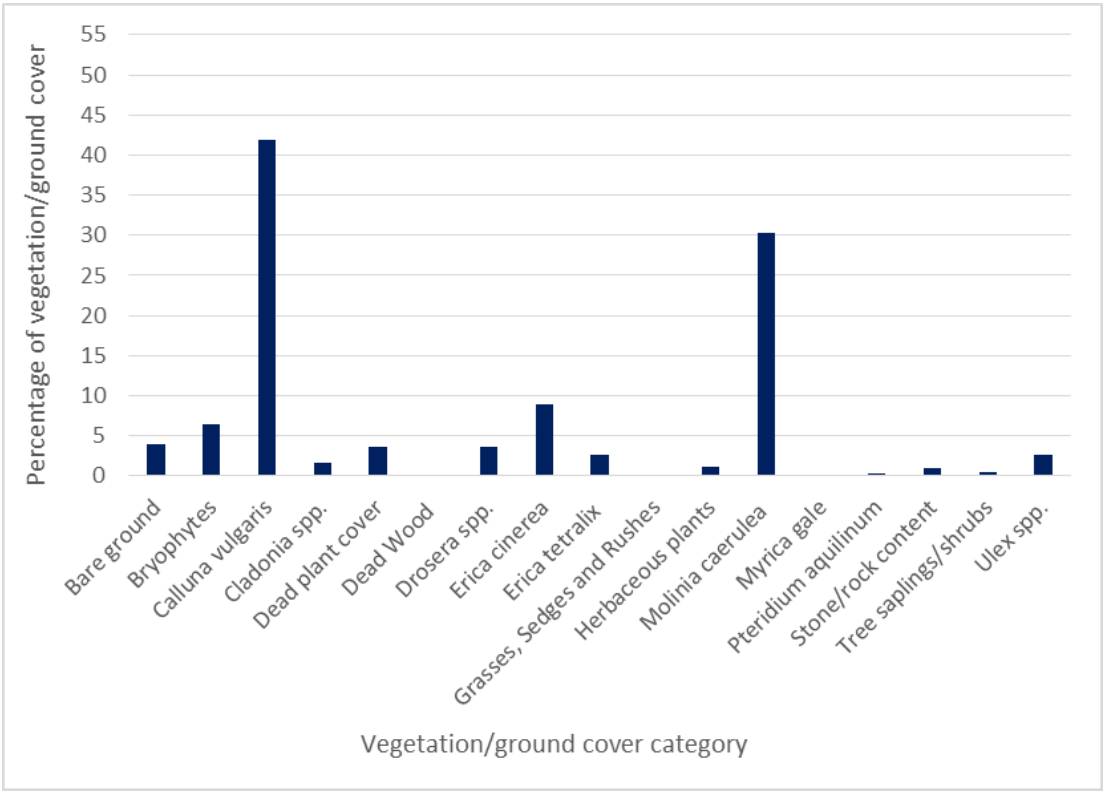

Figure 3.21. Vegetation and ground percentage cover at Shatterford Bottom, near Denny Wood.

The eastern and western transects showed the most ant activity. Both *Myrmica scabrinodis* and *Leptothorax acervorum* individuals were found foraging and one *Lasius alienus* nest, with brood, was found within the *Calluna vulgaris* roots. *T. interruptus* was found at one site on the southern transect; the entrance to the nest was under a stone at the base of *Calluna vulgaris* with dead plant matter surrounding the entrance. The water saturation rating given within the *T. interruptus* 1 m² quadrat was 0 and the mean height of vegetation was 11 cm (± SD 2 cm). Figure 3.22 shows the percentage of ground cover found within a 1 m² quadrat around the nest.

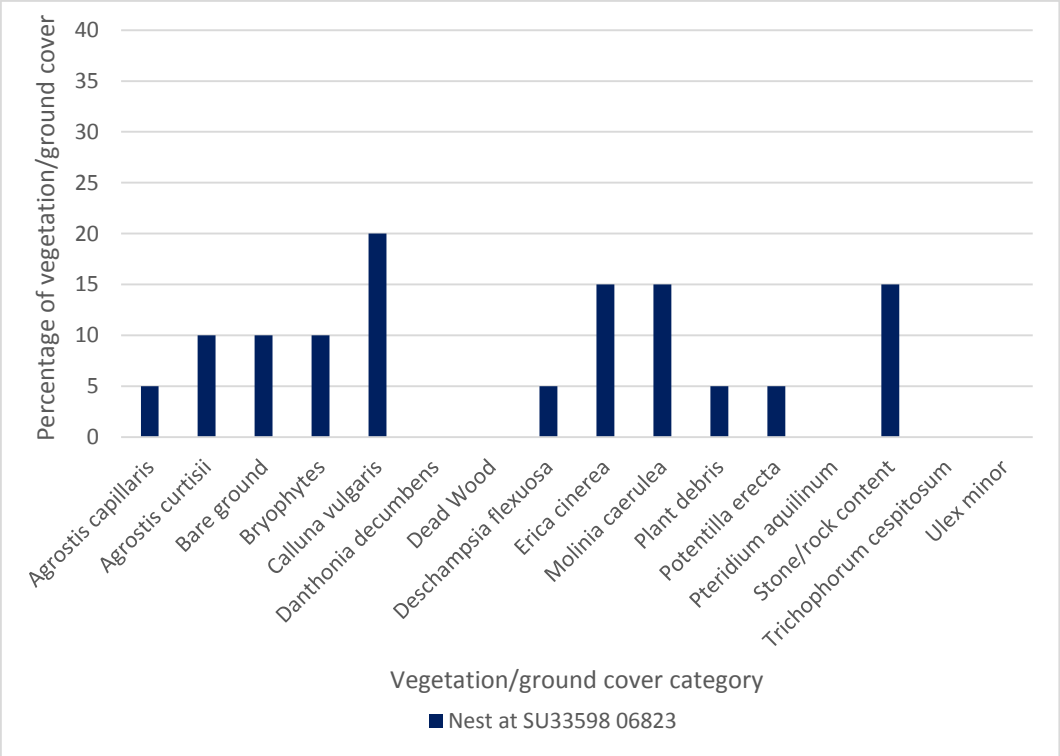

Figure 3.22. Percentage cover of each species within 1 m² of *T. interruptus'* nest.

3.1.11 Yew Tree Heath

NGR: SU3700006166

***T. interruptus* found; site suitable**

Site Description

Yew Tree Heath (Figure 3.23) is bordered by Black Down to the west, Dibden Bottom and the Bealieu River to the east and a series of inclosures and Pottern Ford to the north. The four 50 m transects were carried out on dry heathland to the south of Yew Tree Heath, close to the unnamed road which runs along the southern edge of the heath.

Figure 3.23. Yew Tree Heath.

The site was given a water saturation rating of 0 and featured dry heathland vegetation; primarily *Calluna vulgaris* in all stages of development, pockets *of Erica cinerea*, dense clusters of *Ulex minor* and *Pteridium aquilinum* interspersed with bryophyte cover and the occasional flowering *Cladonia* spp. Figure 3.24 shows the percentage cover of vegetation and ground cover within 17 categories. The site sloped down to the north through a border of *Ulex minor* where it led into an open area of damper heathland. There was evidence of pony, cattle and rabbit grazing, especially on the western transect; the mean height of vegetation across the transects was 25.7 cm (± SD 11.03 cm), the mean elevated by banks of *Ulex minor.* Stone cover at 7.6% was higher than most other sites in this survey.

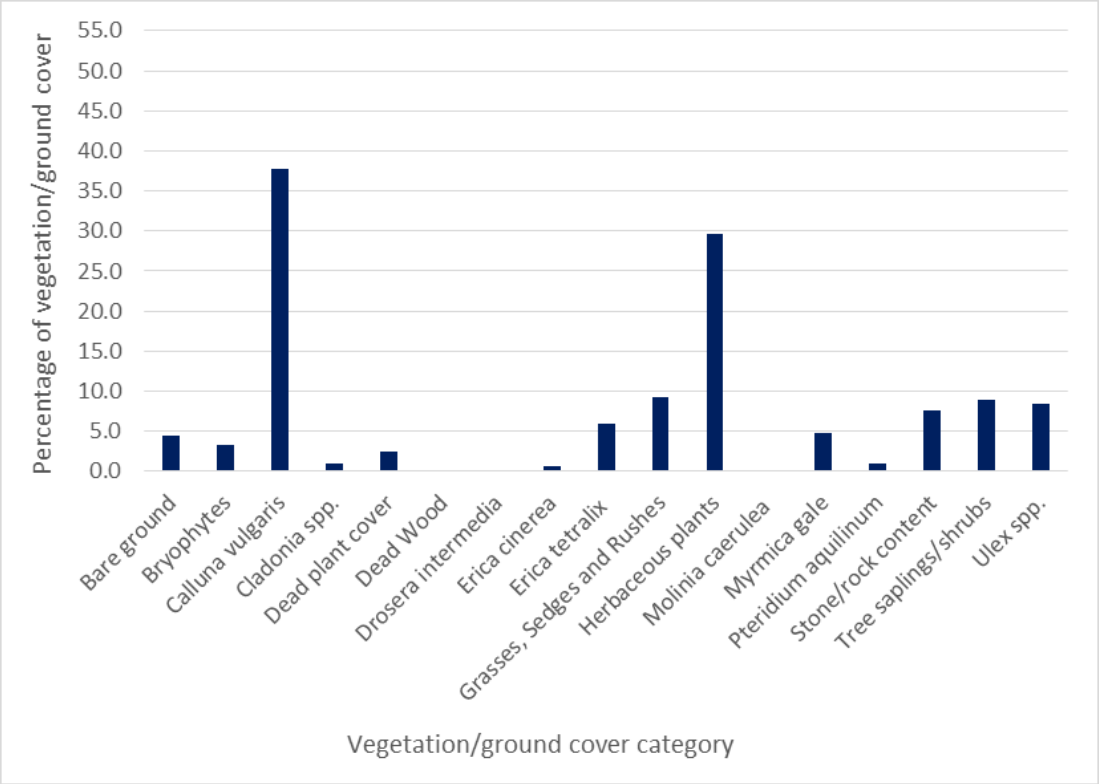

Figure 3.24. Vegetation and ground percentage cover at Yew Tree Heath.

Three underground *T. interrruptus'* nests were found; all on the western transect. The entrance to each nest was indicated by a small hole, approximately 0.5-1.0 cm in diameter in the ground. Two entrances were found under stones amidst dead vegetation cover, while the other was found at the base of a clump of *Deschampsia flexuosa.* Figure 3.25 shows the percentage of ground cover found within a 1 m² quadrat around each nest. At Yew Tree Heath, both *Calluna vulgaris* and *Erica cinerea* were found in the quadrats; however, in all three cases, the *Ericaceae* cover was sparse, degenerate and there was at least 10% of bare ground available in the quadrat. In all three cases, nests were found within 10 cm of bare ground. The mean height of vegetation within the quadrats was 11 cm (±SD 3 cm). Several *Formica cunicularia* foragers were found amongst the *Calluna vulgaris* and three *Myrmica scabrinodis* nests, with brood, were found within the *Sphagnum*. *Myrmica ruginodis* foragers were found within the grass close to the road.

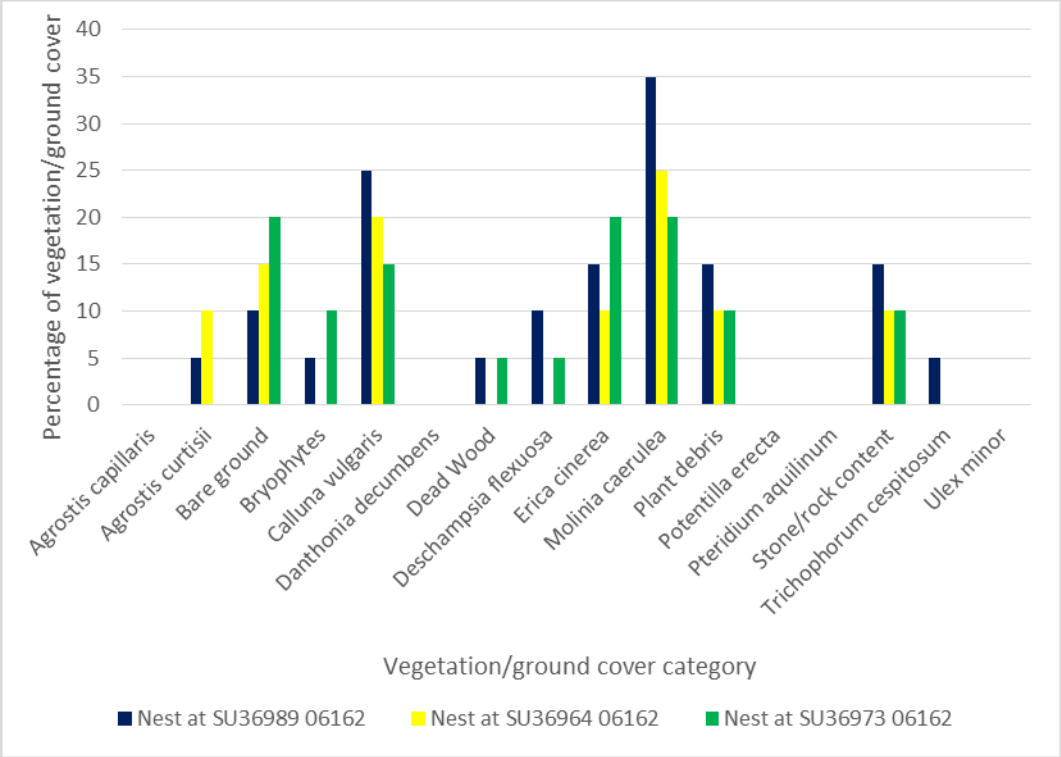

Figure 3.25. Percentage cover of each species within 1 m^2 of a *T. interruptus'* nest.

3.2 Current status of the population within the New Forest

3.2.1 Distribution and habitat suitability overview

Across the 11 sites within the New Forest, eight sites (73%) were considered to have suitable habitat to support *T. interruptus* populations. Out of the eight sites, *T. interruptus* nests were recorded in 3 sites (37.5%) (Table 3.1 and Figure 3.26).

Other ant species found across the sites included *Formica cunicularia*, *Lasius niger*, *Lasius alienus*, *Myrmica scabrinodis*, *Myrmica ruginodis and Leptothorax acervorum.* In sites where *T. interruptus* nests were found, all of the other six other ant species were also found to be present. This included nests, foragers and alates (sexual, winged ants).

Table 3.1: Location, habitat suitability and number of *T. interruptus* nests recorded at each site within the New Forest. NGR coordinates refer to the driest point of each site where the four transects meet.

No.	Location	NGR			Habitat suitability	No. nests
1	Black Down	SU	35147	06566	Y	0
2	Dibden Bottom 1	SU	39216	06997	N	0
3	Dibden Bottom 2	SU	39171	07229	Y	0
4	Dur Hill Inclosure	SU	19286	01051	N	0
5	Matley Bog	SU	33318	07428	Y	0
6	Matley Heath	SU	34002	06797	Y	0
7	Matley Passage, near campsite	SU	32792	07498	Y	0
8	Matley Passage, west of road	SU	33120	07213	N	0
9	Shatterford Bottom	SU	34093	06054	Y	2
10	Shatterford Bottom, near Denny Wood	SU	33600	06824	Y	1
11	Yew Tree Heath	SU	37000	06166	Y	3

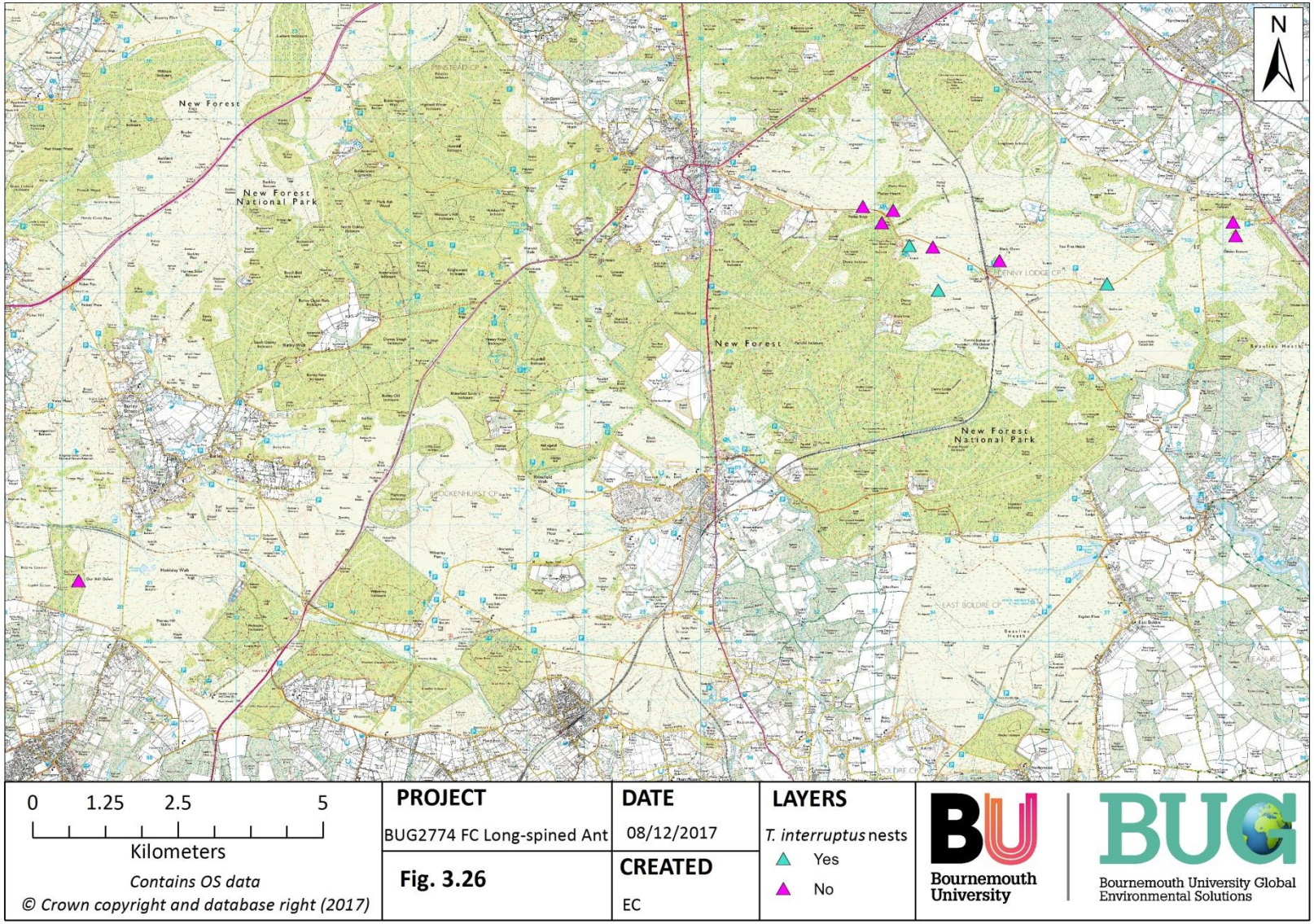

Figure 3.26. Map of the 11 sites where the *T. interruptus* survey was undertaken. Turquoise and magenta triangles indicate *T. interruptus* nests presence and absence, respectively.

3.2.2 Significant variables

As the data collected was revealed to have a nonparametric distribution, a Mann-Whitney U test was used to show any significant differences between the categories of vegetation/ground cover recorded in the 60 null 1 m² quadrats with the vegetation/ground cover recorded in the six 1 m² quadrats containing *T. interruptus'* nests.

Bare ground

The results of the Mann Whitney U test showed a significant difference in percentage cover of bare ground between quadrats with *T. interruptus* nests and null quadrats (absent of *T. interruptus* nests) (P<0.01). The boxplot in Figure 3.27, which depicts the difference in the percentage cover of bare ground between the two groups (quadrats with *T. interruptus* nests and null quadrats), shows all values in the six quadrats with *T. interruptus* nests to be over 10% cover of bare ground, whereas the median line for the 60 null quadrats lies at 0 with the upper whisker line extending to 10%.

This is not entirely surprising, as *T. interruptus* is a thermophilic species, found in dry, warm areas where bare sand or soil exists (Børgesen, 2000) and where the earth has been warmed by insolation. Ants, as ectotherms, need to create a nesting structure which maintains a warmer microclimate than the ambient air and ground temperature, as this allows brood to develop as well as providing warmth for overwintering (North, 1999). *T. interruptus* nests are constructed underground, typically in a single chamber (Børgesen, 2000), usually under stones or at the base of plant roots. After winter hibernation, all colony members gather in the warm soil at the top of the nest during spring before bringing up the overwintered, unpigmented brood which may be covered by plant debris to protect them from ultra-violet light (Børgesen, 2000). Warm temperatures, which are created by the insolation of bare ground, are needed to enable larval growth (North, 1999), which may be suppressed if temperatures are unseasonal. In cold weather, brood can be taken back down into the chamber where the microclimate is more stable.

Interestingly, the Mann Whitney U test did not show a significant difference in plant debris between quadrats with *T. interruptus* nests and null quadrats (P<.05); however, the ground cover around the three nests found at Yew Tree Heath all contained plant debris of at least 10% (Figure 3.25). It is likely that the test result has been influenced by one of the nests at Shatterford Bottom (SU 34101 06100), which had no plant debris in the 1 m² surrounding zone. The entrance to the nest was at the base of a pocket of *Erica cinerea* in an area with a higher percentage of building *Calluna vulgaris* than at the other nests. Plant debris has also been found in most of the null quadrats, originating mostly from established and mature *Calluna vulgaris* and therefore it does not appear to be a significant factor.

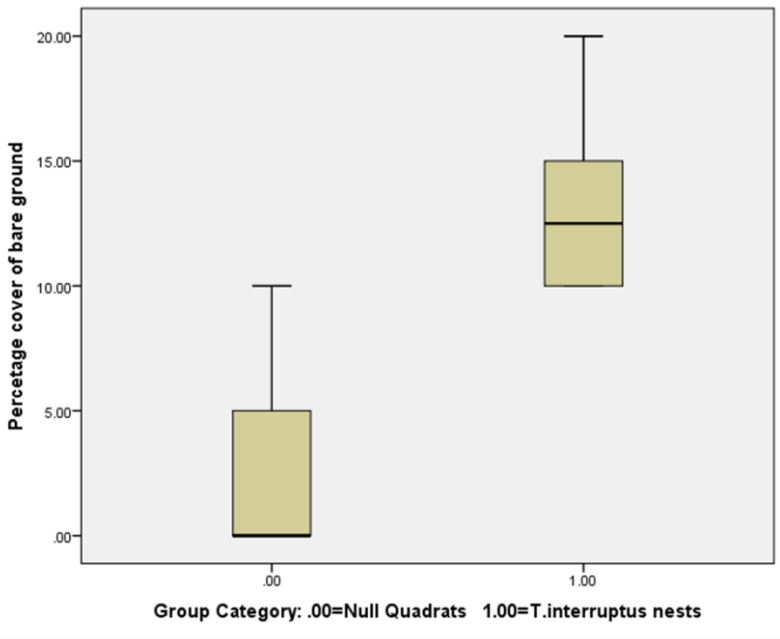

Figure 3.27. Bare ground cover in *T. interruptus* nest quadrats vs. with null quadrats.

Stone/rock cover

The Mann Whitney U test showed a significant difference in the stone/rock percentage cover between quadrats with *T. interruptus* nests and null quadrats ($P<0.01$). Figure 3.28 shows the lower quartile in the quadrats with *T. interruptus* nests to begin at 10% and extend to 15% whereas the median line in the null quadrats lies at 0 with four outliers at 5%. Three of the six nests were located under stones, two at Yew Tree Heath and one at Shatterford Bottom, near Denny Wood.

This result is not unexpected as research has shown that ants' nests are frequently placed under stones or rocks to provide protection from predation and invasion while reducing loss of heat to the soil through conduction (Brian, 1977). Børgesen's (2000) research on *T. interruptus* nest design in Denmark refers to the construction of underground nest chambers with entrances located under small stones in exposed, windswept areas, which suggests that the stone cover is being used to help regulate the nest's humidity and temperature. Børgesen (2000) describes the stones as characteristic; generally small and flat with an area of 15-50 cm² and 2-3 cm in depth. In this study in the New Forest, stone/rock cover in nest quadrats was not found to be characteristic in size or shape, perhaps due to the dearth of available stones at the sites surveyed.

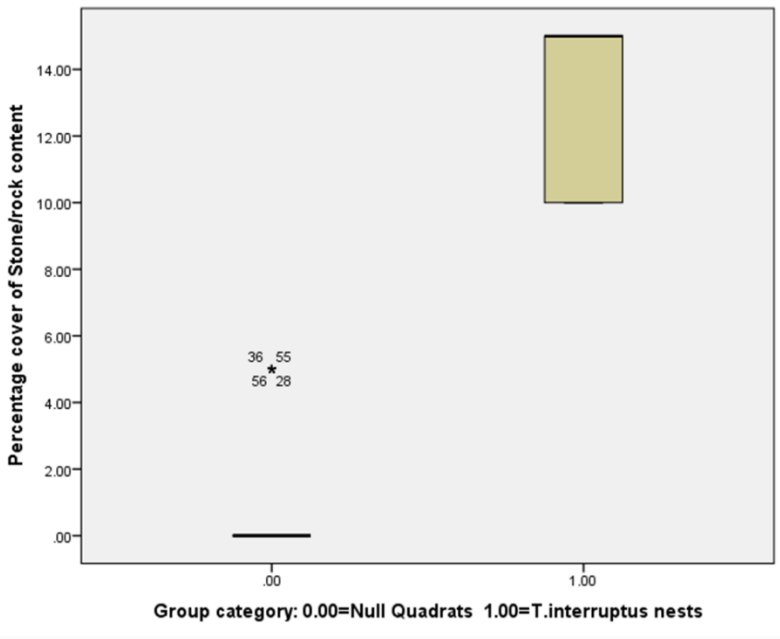

Figure 3.28. Stone/rock cover in *T. interruptus* nest quadrats vs. with null quadrats.

Plant cover

Percentage cover of both *Erica cinerea* and *Deschampsia flexuosa* were found to be significantly different (P<0.05) between quadrats with *T. interruptus* nests and null quadrats. Figure 3.29 shows the median line of *Erica cinerea* cover in the quadrats with *T. interruptus* nests at 15% while the interquartile range is 10-15%. Conversely, the median line in the null quadrats is 5% while the interquartile range 5-10%. All six *T. interruptus* nests were found to have *Erica cinerea* cover of at least 10% while only 70% of null quadrats had some *Erica cinerea* cover.

Figure 3.30 shows the differences in percentage cover of *Deschampsia flexuosa* between quadrats with *T. interruptus* nests and null quadrats. While the median line in the quadrats with *T. interruptus* nests is 3%, the interquartile ranges from 0-6% and the upper whisker extends to 10%. This contrasts with the null quadrats where the median line lies at 0 and there is one outlier at 5%. 50% of the quadrats with *T. interruptus* nests were found to have *Deschampsia flexuosa* cover of at least 10%. The mean height of *Erica cinerea* and *Deschampsia flexuosa* cover combined was 10 cm (SD ± 2.8 cm) and all nests were found in lightly grazed areas. Notably, *Erica cinerea* cover in the quadrats with *T. interruptus* nests was relatively sparse and generally in the building or established stages; *Deschampsia flexuosa* was found in distinctive, isolated tufts within quadrats with a maximum of 10% cover overall.

The association of *T. interruptus* with *Erica cinerea* and *Deschampsia flexuosa* is possibly due to their shared preference for dry heathland habitat; supported by Børgesen's (2000) research in Denmark which found that *T. interruptus'* colonies favoured dry, open habitats with sparse, short vegetation and more rarely, cushions of *Polytricum* and reindeer lichen under which to excavate nests. Plants typically within favoured biotopes included *Corynephorus canescens* (Grey hairgrass) and degenerate *Calluna vulgaris,* where the ant was found to nest within the root system.

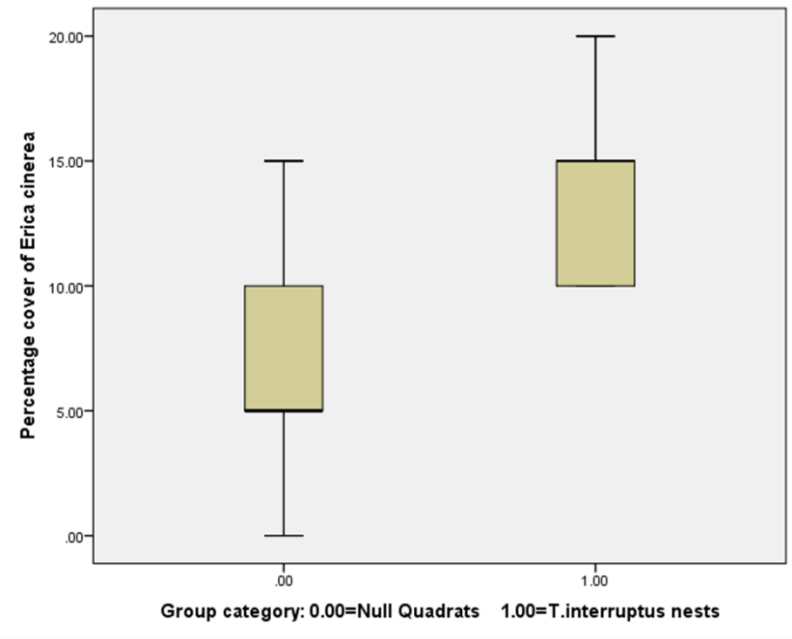

Figure 3.29. *E. cinerea* cover in *T. interruptus* nest quadrats vs. with null quadrats.

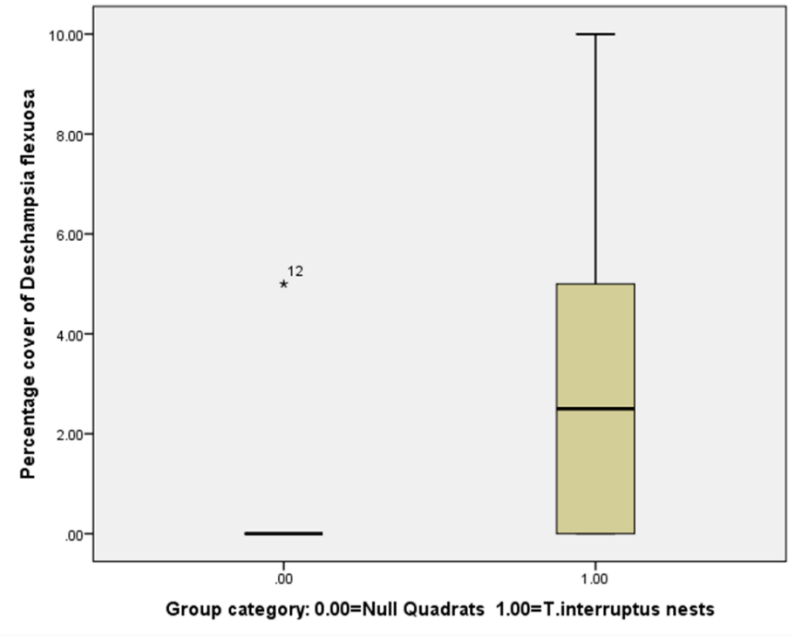

Figure 3.30. *Deschampsia flexuosa* cover in *T. interruptus* nest quadrats vs. with null quadrats.

It has been suggested that there is an association between *T. interruptus* and plant cover, as this creates a readily available supply of dead plant matter for larval protection from sun exposure, in addition to the prey foraging opportunities presented. Ants are an omnivorous insect with a varied diet based on nectar, soft fruits, small invertebrates, seeds and aphid honeydew (Brian, 1977). Nectar, fruits, plant phloem sap and honeydew are rich in sucrose, fructose and glucose, providing

energy, while the consumption of invertebrates provides amino acids and protein for larval growth. Field observations of *T. interruptus* in Denmark (Børgesen, 2000) noted the storing of food items, such as dead invertebrates and plant matter within small stockpiles away from the brood. Distinct hunting strategies were also observed in the study; workers were seen to use a "Jumping Jack" system of group attack which involved a well-timed leap into the midst of a party of feeding prey animals forcing one or more into the ant's mandibles and a more directed form of attack where an individual prey insect was stalked for some time before it was leapt upon.

Conversely, a significant negative association was found with the percentage cover of *Calluna vulgaris* ($P<0.01$) and *Cladonia* spp ($P<0.01$) between *T. interruptus* nest quadrats vs. null quadrats. Figure 3.31 shows the median line for *Calluna vulgaris* cover in the null quadrats at 40% contrasting with the median line in the quadrats with *T. interruptus* nests at 22%. Although *T. interruptus* nests have been reported at the base of *Calluna vulgaris* plants in several studies (Børgesen, 2000, Lee, 2007), it is significant that plant cover has been at the degenerate/dead stage when this has been reported. During this study, the cover of *Calluna vulgaris* throughout the transects at Yew Tree Heath and the two sites at Shatterford Bottom, was at the building, established or degenerate stages, with the mean percentage cover of *Calluna vulgaris* across all three sites at 33% and a mean height of 32 cm (± SD 9 cm). Noticeably, over 45% of the *Calluna vulgaris* was at the degenerate stage in all of the *T. interruptus* nest quadrats. During the degenerate stage the plants spread open at the centre exposing patches of bare ground which provide the warm, microclimate needed by *T. interruptus.*

Figure 3.32 shows a significant difference in *Cladonia* spp. cover between *T. interruptus* nest quadrats vs. null quadrats. *Cladonia* spp. was not found in any of the *T. interruptus* nest quadrats suggesting, perhaps, that the consequent reduction of bare ground in quadrats where *Cladonia* spp. is thriving is unfavourable to *T. interruptus*.

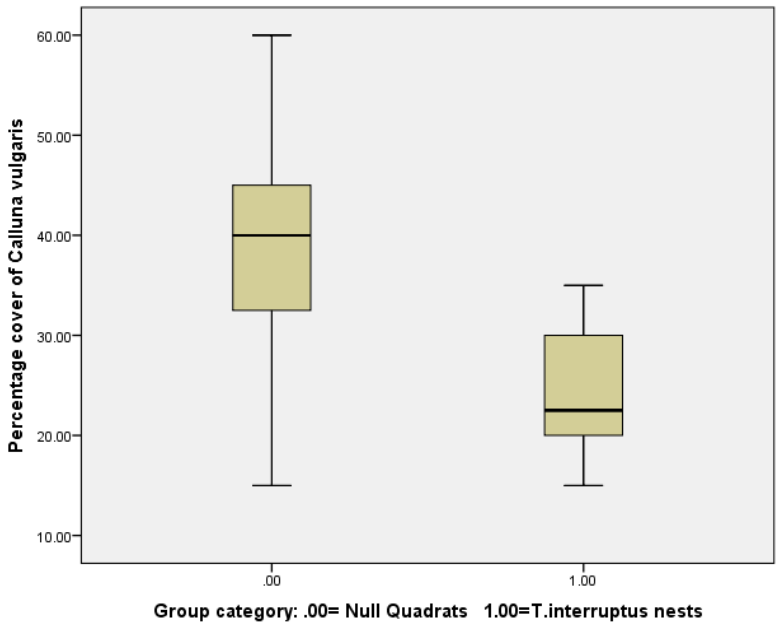

Figure 3.31.*Calluna vulgaris* cover in *T. interruptus* nest quadrats vs. with null quadrats.

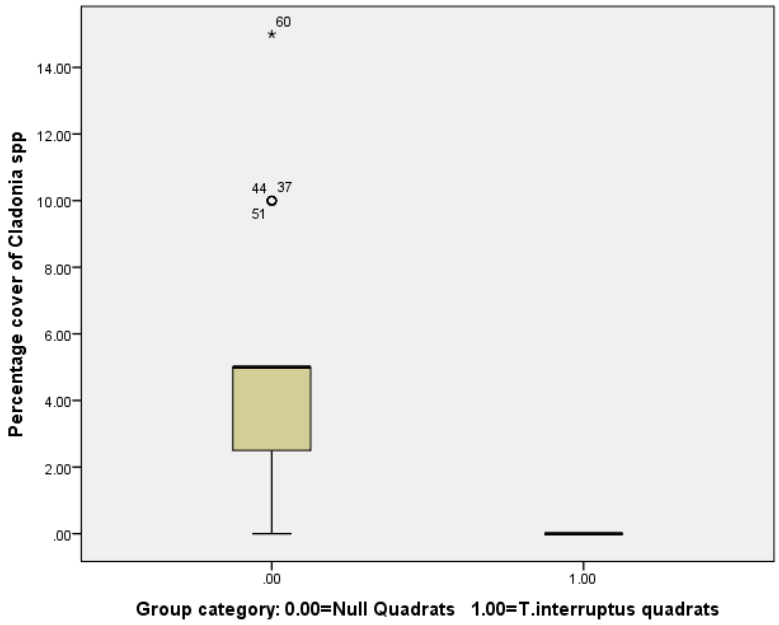

Figure 3.32. *Cladonia* spp. cover in *T. interruptus* nest quadrats vs. with null quadrats.

3.2.3 Ant Competition

Six other ant species were found in the three sites where *T. interruptus* nests were recorded. At Yew Tree Heath where the highest number of *T. interruptus* nests (three) was recorded, three *Myrmica scabrinodis* nests and four *Myrmica ruginodis'* nests were found, in addition to five *Formica cunicularia* foragers. At Shatterford Bottom, where two *T. interruptus'* nests were found, one *Lasius niger* alate was recorded in addition to four *Myrmica scabrinodis* nests. At Shatterford Bottom, near Denny Wood, one *T. interruptus'* nest was found in addition to two *Myrmica scabrinodis* foragers, four *Lasius acervorum* foragers and one *Lasius alienus* nest. Figure 3.33 shows the recorded ant activity across the three *T. interruptus'* sites.

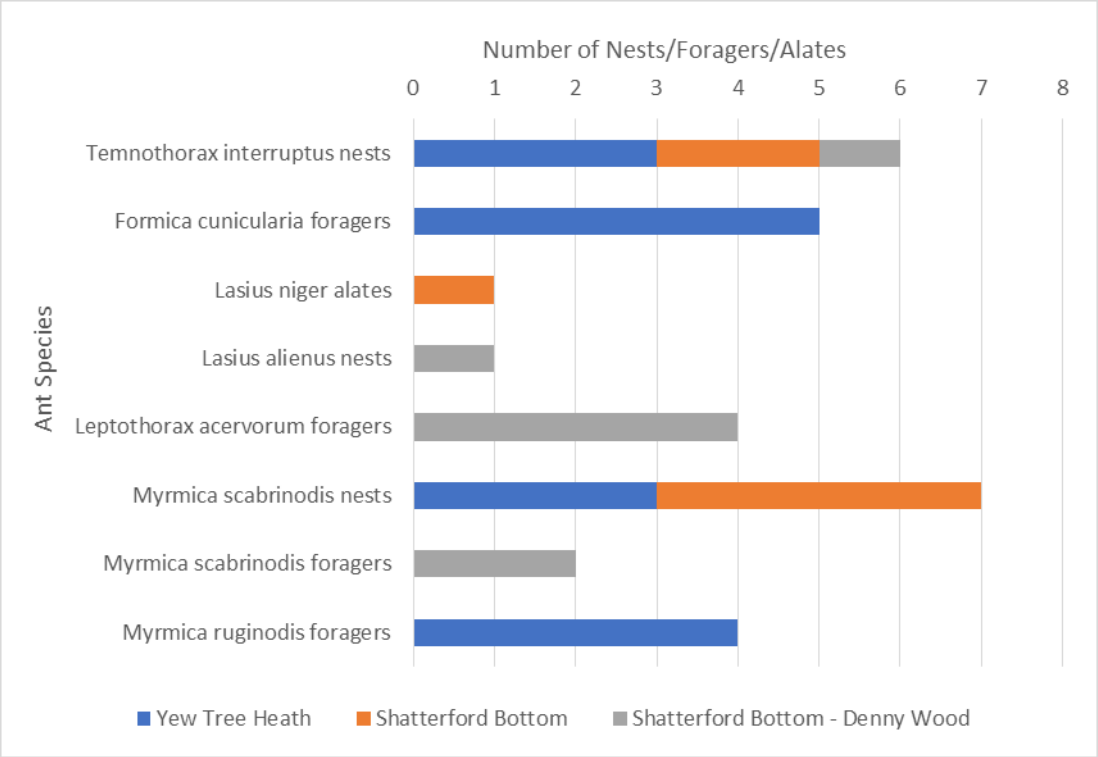

Figure 3.33. Ant activity at the three sites where *T. interrruptus* nests found.

Thiel and Köhler (2016) consider interspecific competition to be a main structuring dynamic in local communities, such as heathland sites, where strategies such as aggression and avoidance are routinely employed. To avoid the energy costs associated with confrontation, co-existing species generally construct their nests within different parts of the habitat (Brian, 1977).

At the three sites where *T. interruptus* nests were found, there was evidence of habitat division. At Yew Tree Heath, the three *Myrmica scabrinodis* nests were found within the bryophyte cushions on the southern transect, while the three *T. interruptus* nests were found underground on the western transect, with their entrances concealed under stones and plant cover. The *Myrmica ruginodis* foragers were found on the grassland edge close to the road, while the *Formica cunicularia* foragers were found within the denser areas of *Calluna vulgaris*.

At Shatterford Bottom, the two *T. interruptus* nests were located at the base of *Erica cinerea* plants, one on the northern transect and one on the southern transect, while the *Myrmica scabrinodis* nests were again found within the bryophyte cushions, and the single *Lasius niger* alate was found on the eastern transect. It is unknown whether the alate had left a nest at this location or had alighted from a distant nest and was attempting to establish a new colony at Shatterford Bottom. No other *Lasius niger* acitivity was seen at the three *T. interruptus* sites, which could be explained by the preference shown by *Lasius niger* for wetter, cooler conditions with more dense vegetation where coccids can be found on *Molinia caerulea* grasses, nectar collected from *Erica tetralix* cover and aphids harvested on woodland cover (Brian, 1977).

At Shatterford Bottom, near Denny Wood, the single *T. interruptus* nest recorded was under stone/*Calluna vulgaris* cover on the southern transect, while the *Myrmica scabrinodis* and

Leptothorax acervorum foragers were found on the eastern and western transects. *Lasius alienus*, which shares with *T. interruptus*, a preference for very dry ground and *Calluna vulgaris* cover, was found nesting on the eastern transect.

Brian (1977) reports that, while aggression and predation are common within ant communities, each ant species has developed defence strategies to minimise the likelihood of attack after an encounter with a different species. Børgesen (2000) states in his research on *T. interruptus* in Denmark, that the species generally coexist peacefully with other ant species, including *Lasius niger*, *Lasius alienus* and *Leptothorax acevorum,* which are all larger and faster than *T. interruptus*. Børgesen (2000) refers to encounters observed between *T. interruptus* and the larger *Formica cinerea* species recorded in Denmark, where the latter made a hasty retreat after touching antenna with a *T. interruptus* worker. The research suggests that *T. interruptus* ants may have a chemical repellent which effectively deters potential predators as the worker ant was seen to vigorously clean her antenna after encountering the *Formica cinerea* forager.

3.2.4 Historic trends

T. interruptus has been recorded at ten sites in the past 46 years, based on NBN database, HBIC and Invertebrates of the New Forest (Table 3.1). Out of the ten sites for which historical records are available, seven showed a decrease, and three exhibited no change (Table 3.2 and Figure 3.34).

Table 3.2: Comparison of *T. interruptus* previous nests records based on NBN database, HBIC and Invertebrates of the New Forest, with records collected during this survey (2017).

No.	Location	Previous records	2017 nests records	Trend
1	Black Down	1980	Not present	Decrease
2	Dibden Bottom 1	1980	Not present	Decrease
3	Dur Hill Inclosure	Date unknown	Not present	Decrease
4	Matley Bog	1971	Not present	Decrease
5	Matley Heath	2002	Not present	Decrease
6	Matley Passage, near campsite	2007	Not present	Decrease
7	Matley Passage, west of road	2007	Not present	Decrease
8	Shatterford Bottom	1970	2 nests	No change
9	Shatterford Bottom, near Denny Wood	1977	1 nest	No change
10	Yew Tree Heath	1980	3 nests	No change

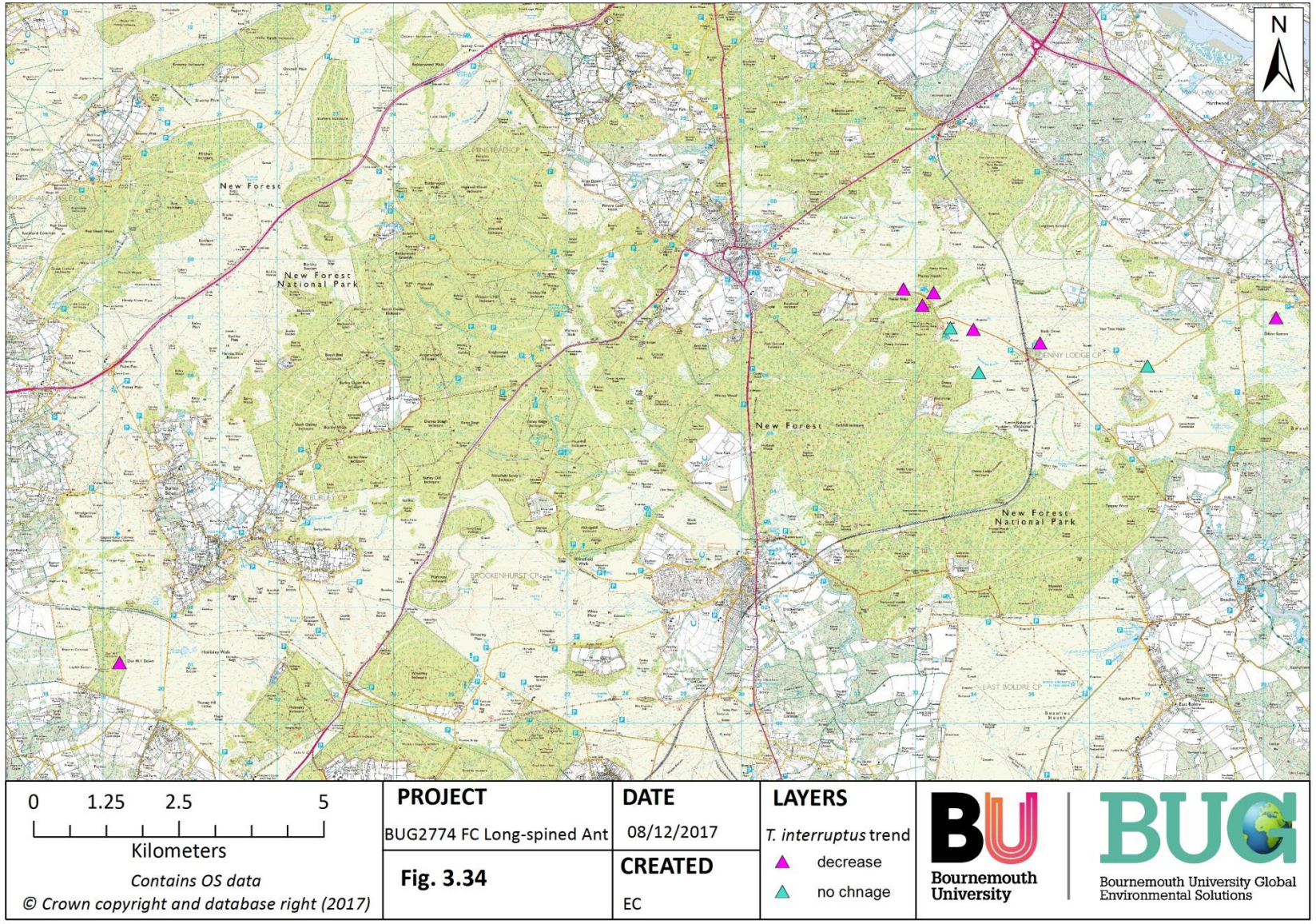

Figure 3.34. Historical trend in *T. interruptus* nests.

4. RECOMMENDATIONS FOR FUTURE WORK AND ACTIONS

The dry, open heathland and sparse, short vegetation favoured by *T. interruptus* in the New Forest is a vulnerable habitat threatened by ecological succession, heathland fires, changes to the local grazing regime, nutrient enrichment and the trampling of delicate vegetation at key building stages (Børgesen, 2000). Uncontrolled, dense *Ericaceae* growth can quickly reduce the warm, microclimate created by bare ground which is needed by *T. interruptus* for larval development, to restore glandular activity after the costly winter hibernation and to allow sexual organs to develop (Haatanen et al., 2015).

Similarly, the growth of scrub, tall dominant grasses and woodland will rapidly diminish the suitability of heathland areas for *T. interruptus* nesting sites, as the ground becomes shaded and the temperature drops. *T. interruptus* favours habitats where a mosaic of sparse *Ericaceae* cover at all stages of development is found; the degenerate stage is as important as the earlier stages, as dead plant debris is used to cover larvae brought up above ground and very mature *Ericaceae* cover opens up bare patches of ground within the plant when it becomes degenerate.

To increase the probability of species persistence at individual sites, management should concentrate on maintaining or creating suitable habitat in the immediate neighbourhood of occupied areas. Recommendations for management in the future are as follows:

- Undertake further targeted monitoring of all occupied and suitable sites to verify presence/absence of Long-spined ant;
- In combination with the above; undertake a desktop feasibility study for the restoration of *Long-spined ant,* including reintroductions and translocations to suitable sites from which the species has been lost;
- Monitor stability of water table height at all sites using appropriate in-situ depth loggers;
- Continue current local grazing regime at all sites;
- Control successional processes and *Ericaceae* growth where grazing is not sufficient as a control.

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APPENDICES

Map 1 (scale 1:60,000) shows all of the *T. interruptus* nests.

Maps 2-3 (scale 1:10,000) show *T. interruptus* nests in separate groups.

List of shapefiles provided:

- LongSpinedAnt_sites_surveyed2017.shp (for each site contains (i) NGR coordinates of the central point where the four transects meet, (ii) number of *T. interruptus* nests recorded), (iii) suitability, and (iv) trend;
- LongSpinedAnt_nests2017.shp (contains NGR coordinates of *T. interruptus* nests recorded).