

THE RANGE EXPANSION OF THE NOBLE JEWEL-WASP, *HEDYCHRUM NOBILE* (HYMENOPTERA: CHRYSIDIDAE), A RECENT COLONIST TO GREAT BRITAIN

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ABSTRACT

Hedychrum nobile (Scopoli) was a species new to Great Britain in 2016 when first recognised in south-east England from specimens dating back to 1998 and 2003. It has been moving northwards throughout Britain over the past 24 years and has successfully colonised eastern and central England. This brood-parasitic chrysidid wasp continues to spread northwards into the East and West Midlands following the distribution of its preferred host, *Cerceris arenaria* (L.). In total, 57 specimens of this new colonist have been identified from the West Midlands during field sampling undertaken in 2022. This article provides updated national distribution maps for all 3 species of jewel-wasp in the genus *Hedychrum* in Britain and indicates movement of *Hedychrum nobile* throughout England since its arrival, discussing how climate change, habitat availability and parasite-host relationships might influence the distribution of this colonising aculeate wasp.

INTRODUCTION

Hedychrum nobile (Scopoli) is a jewel-wasp in the family Chrysididae which is widely distributed throughout continental Europe, including Austria, Denmark, Estonia, Finland, France, Latvia, Lithuania, Norway and Sweden (Linsenmaier, 1959; Paukkunen *et al.*, 2015). The genus *Hedychrum* contains approximately 157 species worldwide, the majority of which are found in the Palaearctic region and in Africa (Kimsey & Bohart, 1991). According to Rosa and Spoon (2012) the European fauna comprises 17 species, with five species being recorded in the Nordic and Baltic countries (Paukkunen *et al.*, 2014). Until quite recently, the only representatives of the genus *Hedychrum* known to exist in Great Britain were *Hedychrum niemelai* Linsenmaier, a species recorded from Cornwall to Kent and north towards Oxfordshire, Norfolk and Lincolnshire, which is considered an aculeate rarity throughout Britain (Falk, 1991; Archer, 2020) and *Hedychrum rutilans* Dahlbom, a species once considered extinct in Britain (Baldock, 2010) but which has had recent records in Essex in 2017 and Kent in 2019 and 2020 (BWARS national dataset, 2023).

Hedychrum nobile was recognised in Britain in 2016 from specimens in southern England, when observations of material of *H. niemelai* were found to contain both specimens of *H. niemelai* and *H. nobile* (Baldock & Hawkins, 2016). Specimens of the newly colonising *H. nobile* were identified from as far back as 1998 from Surrey and 2003 from Essex and have been redetermined as *H. nobile* (Baldock & Hawkins, 2016), placing the likely colonisation of Great Britain before 1998 (pers.comm. R. Edwards). All further discussion of *H. niemelai* and *H. nobile* in this article will be using Paukkunen's interpretation (Paukkunen *et al.*, 2015), unless stated otherwise. By 2016, *H. nobile* was already spreading outwards and had successfully colonised most of East Anglia and southern England, taking advantage of sites with dry sandy soils, such as lowland heaths, acid grassland, sandpits and brownfield sites. Since its

arrival from mainland Europe in the late 1990s, this species has continued its northward expansion throughout England.

This article will inform readers of the brood parasitic ecology of *Hedychrum* jewel-wasps in Britain and update knowledge of the distribution of the newly colonising *Hedychrum nobile* in England, whilst speculating on which factors may be influencing the range expansion of this species.

ECOLOGY AND SPECIES DESCRIPTION

Hedychrum niemelai, *Hedychrum nobile* and *Hedychrum rutilans* are late flying univoltine jewel-wasps which are associated with dry, open, sunny, sandy habitats (Baldock & Hawkins, 2016). They can fly from early June in some districts and stay active until late August (Archer, 2020). The flight period of *H. nobile* has been derived from records of the species within the BWARS dataset as the 3rd June to the 15th September in England (pers. comm. R. Edwards). Sexes of all species are 6–10 mm in length with females typically being slightly larger than males (Paukkunen *et al.*, 2015). In *H. nobile* and *H. niemelai*, the head, scutellum and median segment are a metallic blue or green, while the pronotum, mesonotum and the abdomen can be gold, red or purple. They are generally large and therefore are recognisable compared to other British chrysidids. There is a degree of sexual dimorphism between the sexes, despite males and females looking similar. Males have a green and blue head and mesosoma with a gold metasoma (Fig. 2e), whereas the females have a head and mesosoma similar to the males but possess a pronotum and mesoscutum which are bright red or golden yellow (Fig. 2f) (Paukkunen *et al.*, 2015). In contrast, individuals of *H. rutilans* (Fig. 1a & b) are between 4 and 10 mm in length and have a coppery red colouration on the head, pronotum, mesoscutum and mesoscutellum, which can include hues of metallic blue and green on the ventral areas of the head, metanotum, propodeum, and mesopleuron. Males are prone to greater levels of metallic green and blue whereas females are redder in colouration (Paukkunen *et al.*, 2015).

Despite the morphological and habitat-specific similarities between *H. nobile*, *H. niemelai* and *H. rutilans* all species exhibit differences in their ecology and parasitic biology. As brood parasites, jewel-wasps will seek out the nesting cells of a specific host before entering into their underground chambers to lay an egg hidden within the walls of the cell. On hatching, the brood parasite's egg develops into a parasitoid larva that consumes and subsequently destroys the mature larva or prepupa of its host (Polidori *et al.*, 2010). Jewel-wasps are heavily armoured to carry out this clepto-parasitism and can adopt a rolled up defensive posture when threatened or disturbed (Fig. 2d) (Bolton & Gauld, 1988; Early, 2015).

All three species of *Hedychrum* in Great Britain attack the larvae of crabronid wasps in the sub-family Philanthinae (Paukkunen *et al.*, 2015). *Hedychrum nobile* and *H. niemelai* attack fossorial wasps in the widely distributed genus *Cerceris* (Baldock & Hawkins, 2016), which has seven British species. *Hedychrum niemelai* has been recorded attacking the digger wasps of *Cerceris ruficornis* (F.) and *Cerceris quinquefasciata* (Rossius), which are species restricted to southern England (Morgan, 1980). Morgan (1980) also recorded *Cerceris arenaria* (L.) (Fig. 2a) and *Cerceris rybyensis* (L.) (Fig. 2c) as hosts for *H. niemelai*. Both species are common and widespread throughout England, although absent from Scotland, with *C. rybyensis* also absent from Wales. However, an association between *C. rybyensis* and *H. niemelai* remains uncertain. *Hedychrum niemelai* may also cleptoparasitise *Cerceris quadricincta* (Panzer) based on observations of the individual chrysidid at

nest sites in Colchester in 2002, where the only other *Cerceris* nesting at the site was *C. rybyensis*, an apoid wasp which as yet has no proven association with *H. niemelai* in Britain (Harvey, 2002, pers.comm., J. Early). However, an association between *C. rybyensis* and *H. niemelai* remains uncertain. *Hedychrum niemelai* may also cleptoparasitise *Cerceris quadricincta* (Panzer), based on observations of the individual chrysidid at nest sites in Colchester in 2002, where the only other *Cerceris* nesting at the site was *C. rybyensis*, an apoid wasp which as yet has no proven association with *H. niemelai* in Britain (Harvey, 2002, pers. comm., J. Early). As Harvey's observations pre-date the recognition of *H. nobile* in Great Britain, these might be regarded with some suspicion. In contrast, *H. nobile* has only been recorded attacking the nesting cells of *C. arenaria* in England, a wasp which hunts adult weevils (Curculionidae) in the genus *Otiorhynchus* (Fig. 2b) and nests in fine, sandy compacted soils (Else & Field, 2012). Morgan (1980) records *H. rutilans* as parasitising *Philanthus triangulum* (F.) (Fig. 1c), and *Philanthus coronatus* (Thunberg) on the continental mainland, the latter species has never been recorded in Great Britain.

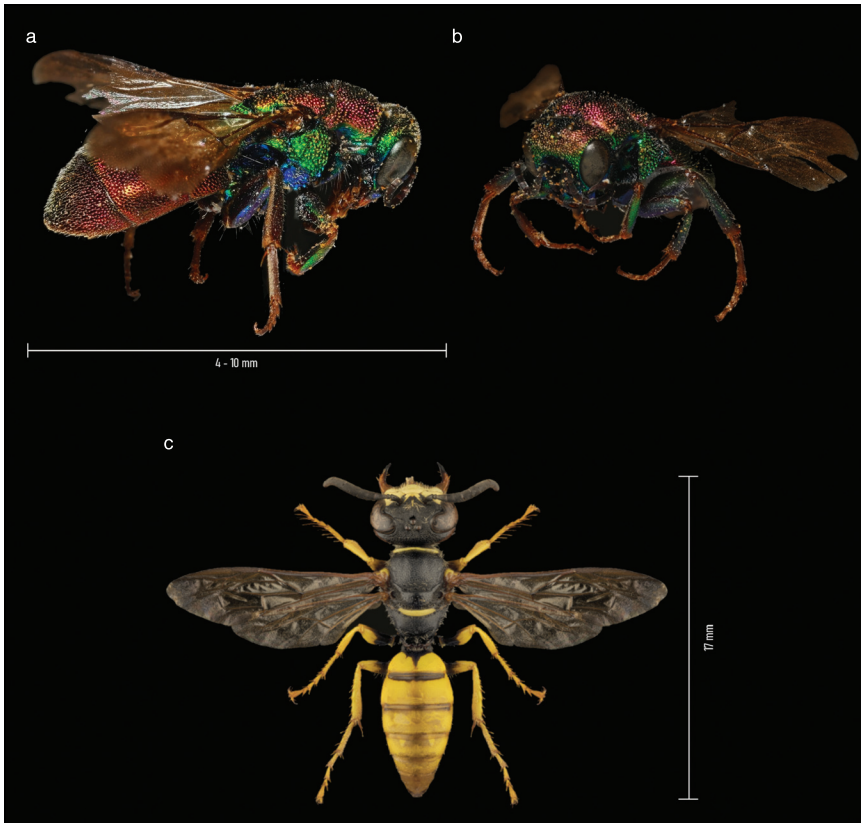


Fig. 1. (a & b) *Hedychrum rutilans* specimen collected by Chawner in 1899, now in the Hope Collection, Oxford ©Andrew Purcell, 2023. (c) female *Philanthus triangulum* ©Bailey Carswell-Morris.

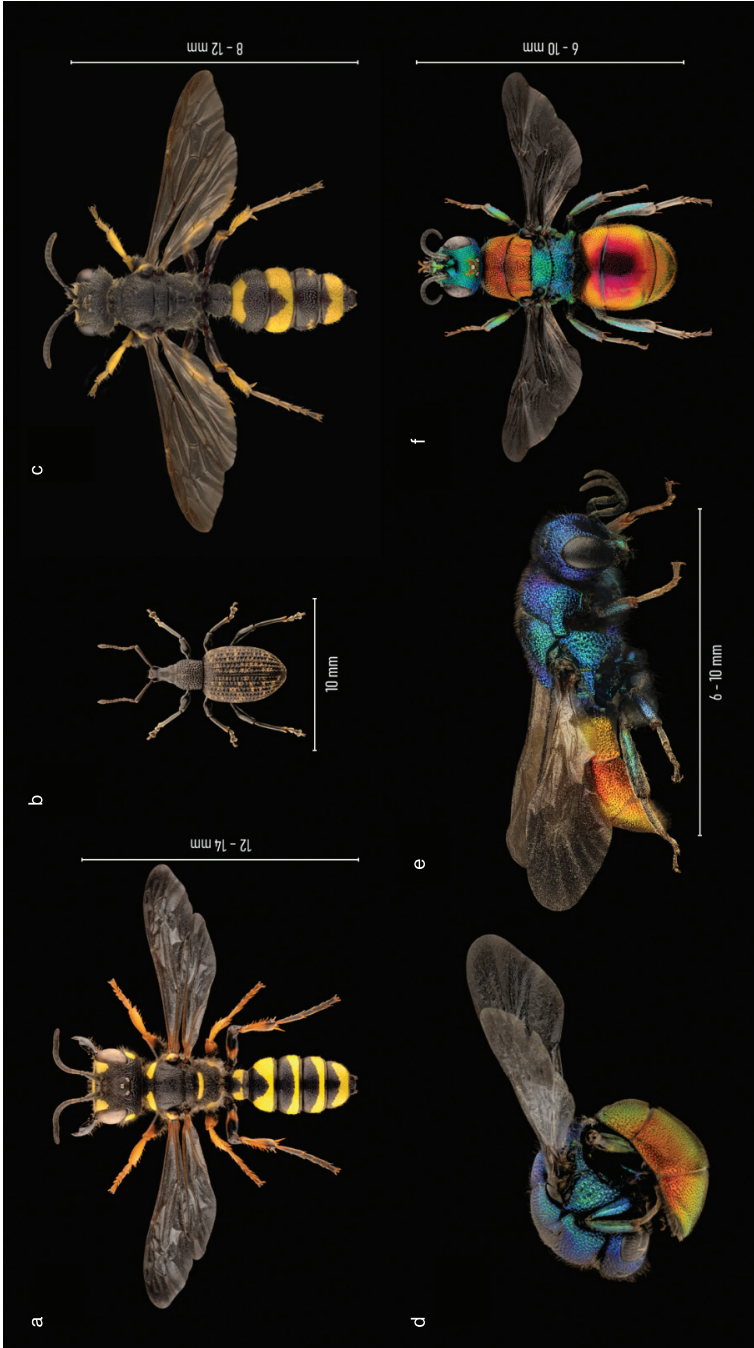


Fig. 2. (a) Female *Cerceris arenaria* (b) female *Otiorhynchus sulcatus* (c) male *Hedychrum nobile* (d) defensive posture of a male *Hedychrum nobile* (e) male *Cerceris rybyensis*. (f) male *Hedychrum nobile* (stacked images prepared by Bailey Carswell-Morris, 2023).

HISTORICAL DISTRIBUTION

The Bees, Wasps and Ants Recording Society (BWARS) compiles data on the distribution of aculeate Hymenoptera throughout Great Britain. The data currently held by the recording scheme for the known members of the genus *Hedychrum* are split into four groups. These include '*Hedychrum niemelai* agg.', an aggregate species complex where the name *Hedychrum niemelai* agg. has been applied to both records of *Hedychrum niemelai* and *Hedychrum nobile* in the past. The dataset also contains records of just *H. niemelai* and just *H. nobile*. Records also exist for *Hedychrum rutilans*. Between 1884 and 2016, the total number of records for '*Hedychrum niemelai* agg.' in the UK was 573. For just *H. niemelai*, *sensu stricto* 149 records were made between 1980 and 2020. These records began in 1980 in the New Forest in Hampshire as the species was recorded frequently throughout south-eastern England. The distribution for this species runs from Cornwall to Kent, north-east to Oxfordshire and Bedfordshire, and progressively further north into Northamptonshire and eastwards into Norfolk.

In comparison, the data for the newly colonising jewel-wasp *H. nobile* revealed that 184 records were made between 2007 and 2022. Its distribution was within Dorset, Hampshire, East and West Sussex and Kent, with a north-eastern expansion into Surrey, Essex, Suffolk and Norfolk, with scattered records from Gloucestershire and Oxfordshire. Using ArcGIS Pro software, this species has been calculated to have increased its range northwards at a rate of 9.85 km per year between 2007 and 2022 (pers. observ.).

The history of *H. rutilans* in Great Britain begins with a specimen caught by E. F. Chawner, a recorder of Symphyta who lived in Lyndhurst in the New Forest in Hampshire in the 1890s. Chawner joined the Entomological Society of London in 1897 and befriended F. D. Morice, an authority on many families of Hymenoptera at the time, who routinely confirmed Chawner's specimens captured in Hampshire. Whilst inspecting Chawner's collection, Morice identified a female *H. rutilans*, as new to the British list, a species which at the time was commonly found throughout Europe and northern France (Saunders *et al.*, 1901). It was also found in the Channel Islands on Jersey, from a specimen collected by E. F. Saunders in 1901. The specimen was caught 'from a piece of rustic woodwork close to a dry and sandy ditch in Chawner's garden' during August of 1899 and so represented what was thought to be the first ever record for the species in England (Saunders *et al.*, 1901). More recently, there have been 17 records of this species between 1989 and 2020. Three of those records occurred in England during the last five years, one in Essex in 2017 and two records for Kent in 2019 and 2020 (BWARS National Dataset, 2023).

CURRENT DISTRIBUTION

Recent records of *H. nobile* in central England indicate a continued northward range expansion for this jewel-wasp. During 2022, entomologists in the West Midlands carried out regular aculeate sampling at sites of relict lowland heath as part of research into how urbanisation and habitat fragmentation influence bee, wasp, and hoverfly assemblages. Timed surveys during the spring (May to June) and the summer (July to August) of 2022 at 26 sites of lowland heath were undertaken using a combination of direct hand searches via sweep netting and pan trapping. In total, 57 small, metallic jewel-wasp specimens were collected from sites from north Worcestershire, Birmingham and the Black Country, and south Staffordshire (Fig. 4). The wasps were swept directly from sandy, compacted footpaths where

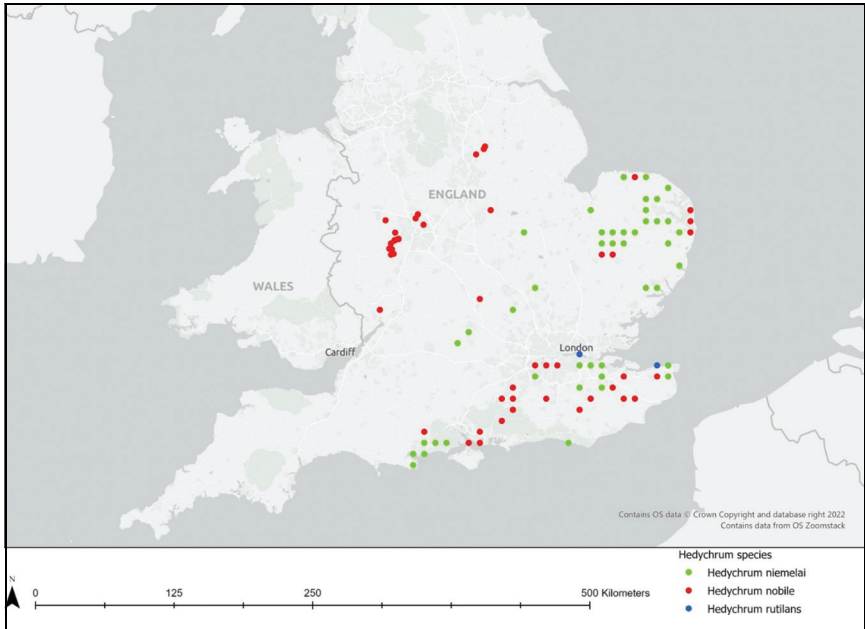


Fig. 3. British distribution of *Hedychrum nobile*, *Hedychrum niemelai* and *Hedychrum rutilans* in 2023 based on BWARS data at 10 km resolution, local sampling in the region and data from Nottinghamshire Biological and Geological Records Centre (NBGRCC) (ArcGIS Pro, 2023).

Cerceris digger wasps were nesting in dense aggregations or were gathered from pan trap samples. Specimens were taken from seven of the 26 sites surveyed, including The Devils Spittleful and Rifle Range SSSI (VC 37), Kinver Edge SSSI (VC 39), Highgate Common SSSI (VC 39), Hartlebury Common SSSI (VC 37), Sutton Park NNR SSSI (VC 38), Brownhills Common SSSI (VC 39) and Pelsall Common (VC 39). The specimens were thought initially to be *Hedychrum niemelai*, but after discussions with several BWARS members in the West Midlands, it was realised that the jewel-wasps might be the recently colonising *H. nobile* (MB, LL, AJ, SF, NJ, BW, RW, pers. comm.). Individual records for specimens thought to be *H. nobile* were made by several aculeate recorders in the region, such as at Dunsley Sandpit in Stourbridge in 2020 by L. Large, the Devils Spittleful and Rifle Range Nature Reserve in Worcestershire in 2020 by R. Winnall and B. Westwood, as well as at Venus Bank in Shropshire by I. Cheeseborough in July of the same year. A male specimen was also taken by N. Jones in Shropshire in 2021 and records had even extended into south Staffordshire, where A. Jukes recorded *H. nobile* at Highgate Common SSSI and Kinver Edge SSSI in 2021 and 2022. Further north-east the species has also been recorded in the East Midlands, with a first record for Nottinghamshire (VC 56) in 2021 at a site of the former Rufford Colliery at Rainworth by T. Sexton (Pendleton, 2022). These records indicate that the species has become more widespread in the Midlands and beyond. An updated set of distribution maps below shows the extent of the ranges of *H. nobile*, *H. niemelai* and *H. rutilans* nationally (Fig. 3), as well as just *H. nobile*'s historic and current range

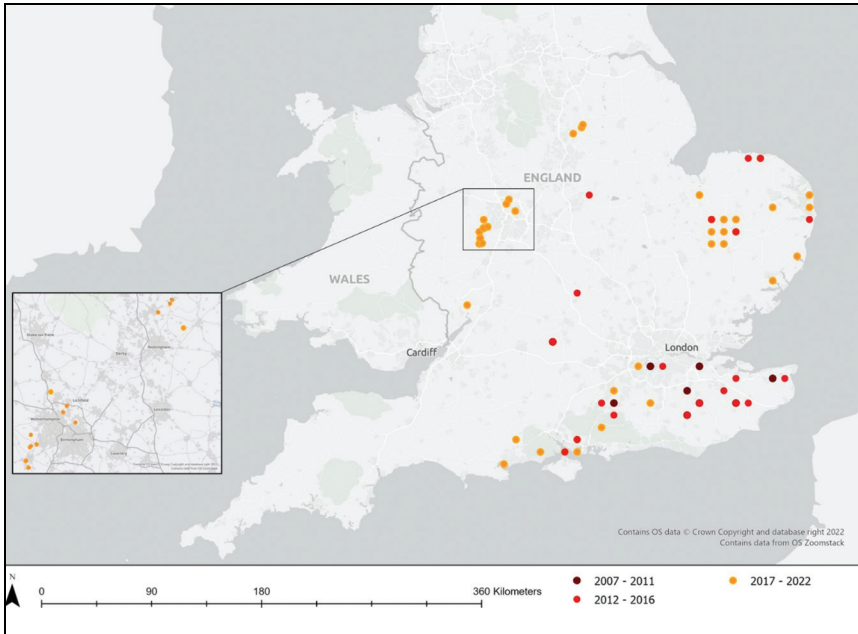


Fig. 4. British distribution of *Hedychrum nobile* in 2023 based on BWARS data and local sampling in the West Midlands at 10 km resolution (ArcGIS Pro, 2023).

(Fig. 4). The latter map shows records of *H. nobile* within the Midlands in 2022. Figure 5 shows a map of the distribution of *H. nobile* compared with that of its host, *Cerceris arenaria*. Records of *C. arenaria* extend beyond Nottinghamshire facilitating the northward expansion of *H. nobile*.

FACTORS INFLUENCING RANGE EXPANSION

Range shifts in invertebrate species have been documented in a number of insects throughout Britain since the early 2000s (e.g., Hill *et al.*, 2002; Pateman *et al.*, 2012; Platts *et al.*, 2019). This is true for both extant species and for colonists which have entered the country either naturally through range expansion or due to anthropogenic influences. A study led by researchers at the University of York analysed over 25 million records of 300 different insect species in Britain, determining that many generalist species are expanding northwards. Platts *et al.* (2019) found that the Roesel's Bush-cricket, *Roeseliana roeselii* (Hagenbach), a native orthopteran, which was once a species confined to the south-east coast of England, has undergone a range expansion into central and north-western England. A similar range expansion was recorded amongst Odonata, with species of dragonfly such as the Emperor, *Anax imperator* Leach and Migrant Hawker, *Aeshna mixta* Latreille increasing their ranges by 17 to 28 metres per day over 40 years (Platts *et al.*, 2019). The increase in distribution was not only noted in species located in southern England but also at more northerly latitudes. For example, the Comma Butterfly,

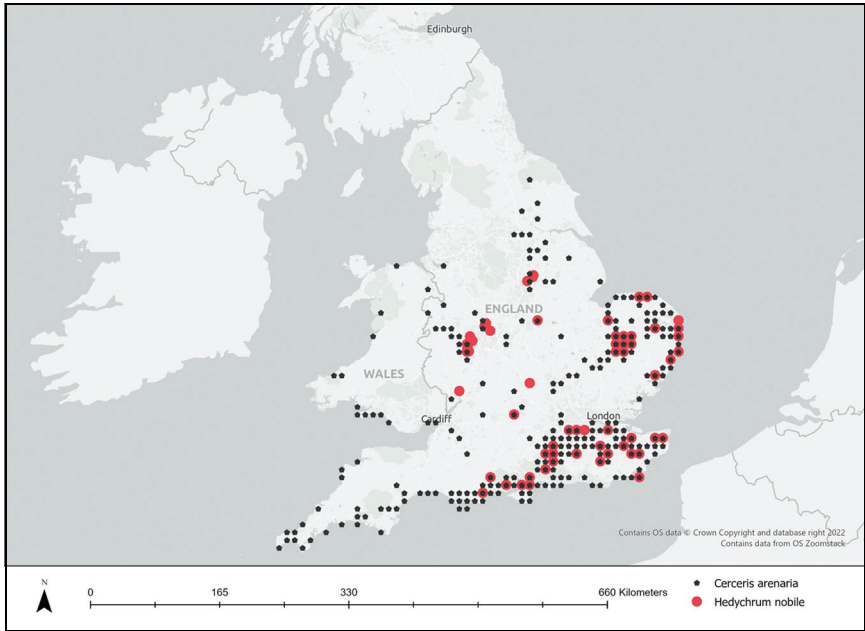


Fig. 5. British distribution of *Hedychrum nobile* overlain with the distribution of *Cerceris arenaria* based on BWARS data, local sampling in the Midlands in 2022 and data obtained from NBGRCG (ArcGIS Pro, 2023).

Polygona c-album (L.), a species widely distributed throughout southern and central England, and with strongholds in the north of England, spread from Yorkshire to Aberdeen in only 20 years (Butterfly Conservation, 2020). Invasive colonist species have also shown shifts in dispersal northwards over short periods of time. For example, the invasive Hemipteran, *Pyrrhocoris apterus* (L.), or 'Firebug', is at the northernmost extent of its European range in Britain. It was historically very rare with only a single Devon population known, but recent data suggest that this species occurs in Surrey, Sussex, Essex, Suffolk, Kent, and Bedfordshire and has started to be recorded in the Midlands and further north (NBN Atlas, 2022). The Harlequin ladybird, *Harmonia axyridis* (Pallas) is an invasive invertebrate species in Britain, colonising in 2004, it has since moved through all of England and is now colonising Scotland (Majerus *et al.*, 2006), travelling 100 km per year over the first 4 years of its establishment (Inside Ecology, 2023). The Tree Bumblebee, *Bombus hypnorum* (L.) was first recorded in Britain in 2001 near Southampton and has since colonised much of England and Wales. This bumblebee was first recorded in Scotland in 2013 and continues to spread northwards, steadily increasing its range (Edwards, 2014).

The effects of temperature and climate change on insect species have been investigated in a number of studies (e.g. Coope, 1995; Hill *et al.*, 2002; Majerus *et al.*, 2006; Milicic, Vujić & Cardoso, 2018; Platts *et al.*, 2019; Rahimi *et al.*, 2021). Significant temperature changes are thought to shift the geographic distribution of insects (including pollinators) (e.g. Coope, 1995; Imbach *et al.*, 2017). Coope (1995) proposed that historically there are three possible scenarios related to a species'

response to regional changes in climate and these were: (1) adaptation to new conditions, (2) migration to more suitable areas and (3) extinction. According to Hill *et al.*, (2002) in a changing climate, species in the northern part of their range will contract to higher elevations as the southern parts of their range become climatically unsuitable, whereas species in the southern part of their range should expand northwards into new suitable areas.

Great Britain has experienced some of the hottest, driest weather ever recorded in the country over the past decade (Fig. 6; Met Office, 2022). Not only was 2022 was the hottest year on record in Britain, with an average annual temperature of 10.03°C, exceeding the previous hottest record set in 2014 with an average of 9.88°C, but the ten hottest years on record since Met Office monitoring began in 1884 all occurred after 2003 (Met Office, 2022). The range expansion of many species could be linked to these extreme temperatures experienced over the past 20 years. However, annual mean temperature is a poor correlate of invertebrate range change when it is usually the adult insect which is most affected during its flight period. Warmer winters will increase mean annual temperatures – but not necessarily have a correlation with range expansion. Although temperature may play a role in facilitating changes to insect distribution, there are several competing factors which may influence why *Hedychrum nobile* has been extending its range into new areas.

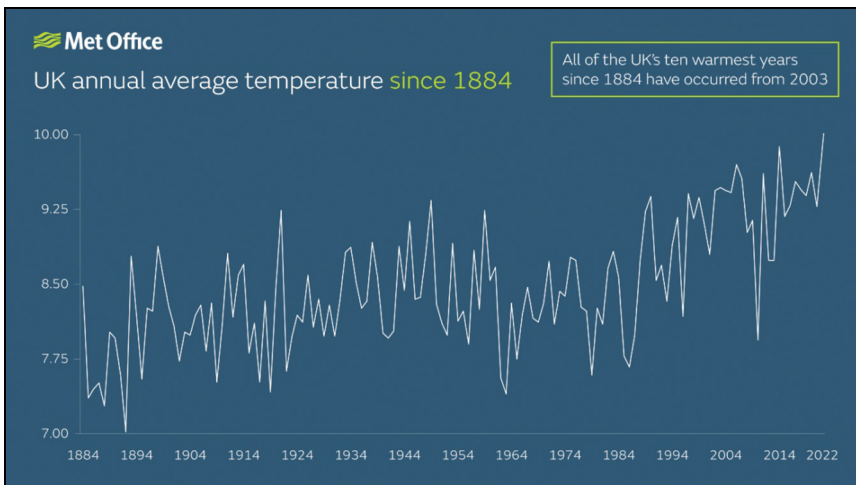


Fig. 6. Annual temperatures in Great Britain between 1884 to 2022 (inclusive). (Met Office, 2022).

Whilst it is likely that climate change underlies poleward and latitudinal expansions of insects, habitat availability also plays a vital role in enabling species to live and nest. For species to expand their ranges in response to climate change, there must be suitable habitat for colonisation (Platts *et al.*, 2019). In a comparative study of lowland heathland in the West Midlands, Falk (2010) stated that the heathlands of Staffordshire and Worcestershire are of national significance, extending the ranges of many species of bee and wasp. During field sampling in the West Midlands in 2022, all 57 specimens of *H. nobile* were collected from sites of lowland heath, several of which were the same sites studied by Falk (2010) and other

entomologists in the early 2000s. Such sites are located on a bedrock of Permian Triassic sandstone and are therefore highly attractive to many nesting psammophiles, including *Cerceris arenaria*, the main host of *H. nobile*. It is possible that the pronounced spread of *H. nobile* into the Midlands has been supported by the availability of suitable habitat for its host, in the form of lowland heaths and sand quarries which are integral parts of the natural, geological, and cultural heritage of the West Midlands.

Alternative Hosts

In several instances during field sampling in 2022, *H. nobile* was swept from sandy foot-paths that contained *C. arenaria* but also another species of *Cerceris* wasp, *Cerceris rybyensis*. The slightly smaller *C. rybyensis* is a hunter of solitary bees and is often found nesting in the same substrates and on sandy footpaths as *C. arenaria* (Else & Field, 2012).

The first record of *H. nobile* in the Black Country was made in Walsall at Brownhills Common SSSI by M. Bloxham (06.vii.2022). During that survey, there was an absence of *C. arenaria* but *C. rybyensis* were plentiful on the same paths where *H. nobile* was collected. *Cerceris arenaria* has never been previously recorded at Brownhills Common, despite six separate surveys on site over the past 20 years. In Warwickshire, *H. nobile* was recorded at a site with no previous record of *C. arenaria*, but which did possess *C. rybyensis* (pers. comm., A. Jukes).

Hedychrum nobile may be attacking an additional host in the form of *C. rybyensis* within the West Midlands, which may enable the species to move into new areas which previously lacked a preferred host. The BWARS national dataset indicates that throughout southern England, *C. arenaria* is a very widespread and common species, whereas in the West Midlands it is less frequently recorded than *C. rybyensis* (Fig. 7). It could be possible that as *H. nobile* colonises northwards into new

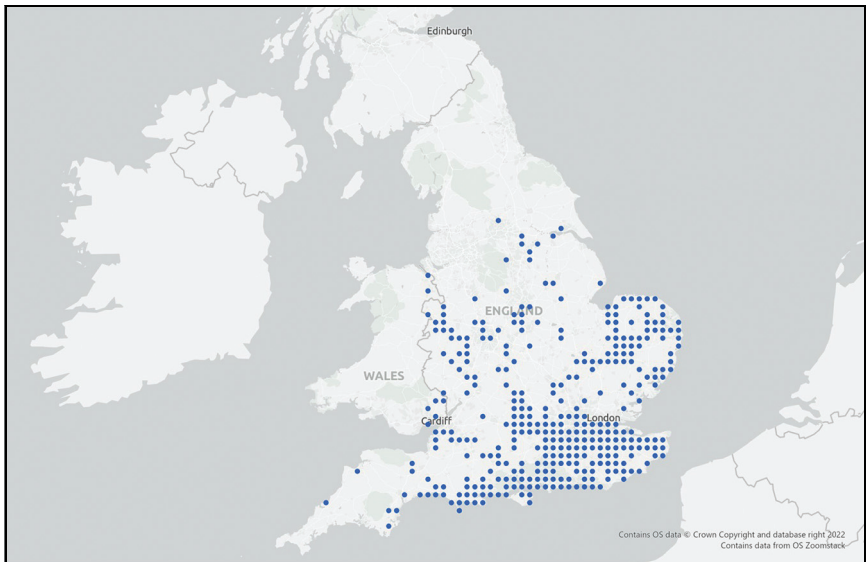


Fig. 7. British distribution of *Cerceris rybyensis* (ArcGIS Pro, 2023).

territories, it will attack the first *Cerceris* that it encounters, in order to establish itself at a site (pers. comm., M. Bloxham). Within the West Midlands, the prevalence of *C. rybyensis* over *C. arenaria* may mean it is initially favoured by *H. nobile* when seeking a host to parasitise and could explain why observations in the West Midlands this year indicated an association between the colonising jewel-wasp and *C. rybyensis*. However, observations of nest entry in Midhurst over several years has alluded to an association between *H. nobile* and *C. rybyensis*, where the availability of *C. arenaria* has been distinctly limited in the past few years. (pers. comm, M. Edwards). This demonstrates that *C. rybyensis* maybe a host for *H. nobile* in Southeast England and not just the midlands.

Once *H. nobile* has become more established at a site, it may revert back to attacking its traditional host, *C. arenaria*. Species at the edge of their range may be pressured into adopting new behaviours and functional traits to adapt to and exploit new environmental conditions, which may include altering their prey selection and subsequently their diet.

Hedychrum nobile attacks various *Cerceris* spp. in mainland Europe including *C. rybyensis* (Polidori *et al.*, 2010). However, *C. rybyensis* is yet to be confirmed as a host for *H. nobile* in Britain. The association between *C. rybyensis* and *H. nobile* was first reported by Alfken (1899). Hamm and Richards (1930) found what was thought to be *H. nobile* around the burrows of *C. rybyensis* in Berkshire (now Oxfordshire), but this was likely to have been a misidentification of *Hedychrum niemelai*. Hamm (1930) recorded *Cerceris quinquefasciata*, the proven host of *H. niemelai*, in the same area. Hamms record of *C. quinquefasciata* supports the argument that the *H. nobile* initially recorded by Hamm and Richards may have been a misidentification of *H. niemelai*, casting uncertainty on whether there has been any association between *H. nobile* and *C. rybyensis* recorded historically in Britain (pers. comm, J. Early). Observations made during field sampling in 2022 suggested a potential association between *C. rybyensis* and *H. nobile* at several sites within the West Midlands, a possibility which is not yet proven.

It is difficult to determine from field observations alone, whether a brood parasite is targeting a new host but it may explain, along with climate change and habitat suitability, how a chrysidid unknown in Britain prior to 1998 has increased its range by 9.58 km per year since its arrival, becoming one of the most common wasps sighted in early summer at many sandy sites throughout western and central England.

Species Colonisation

The Swedish Entomologist A. Dahlbom in his ‘Hymenoptera Europa’ (1843–1854) first described *H. rutilans* from a specimen captured by Koller and stored in the Museum of Vienna under *Hedychrum fervidum*. Although Koller captured the specimen, Dahlbom recognised it as a new species and described the chrysidid as *H. rutilans* when examining Koller’s historic collection. Dahlbom designated Koller’s specimen as ‘*Hedychrum rutilans* Megerl Dahl. Var a’ and became the author of the species. That specimen remains as the lectotype for *H. rutilans* and is stored in the Zoological Museum in Lund, Sweden to this day (Dahlbom, 1854).

The first record of *H. rutilans* in England was Chawner and Morice’s record in 1899, prior to this, the species was not considered to have colonised Britain.

Evidence of the historical presence in Britain of the host of *H. rutilans*, *Philanthus triangulum* was documented as early as the 1830s. In ‘Essays on the Indigenous Fossorial Hymenoptera: A Description of all the burrowing Sand wasps’ Shuckard

(1837) states that *P. triangulum* was new to Britain from a record on the Isle of Wight and near Heron Court in Hampshire by J. Curtis in the 1830s. Shuckard goes on to describe how in 1837 a population of *P. triangulum* was found in mainland England at Snaresbrook in Epping Forest, Essex by Harding. During the 1830s, *P. triangulum* would have been quite rare in England with a very limited range. The BWARS national dataset reveals further evidence of *P. triangulum* in southern England with two records from Woking, Surrey in 1844 and 1860 and two records from Dover, Kent also from 1860 (BWARS National Dataset, 2023).

Shuckard's description of Curtis and Harding's records of the species in combination with historical BWARS data, indicates that *P. triangulum* was distributed throughout southeast England at the time of Saunders and Chawner's records of *H. rutilans*. The records of *H. rutilans* by Chawner and Saunders were the last for this species for a century and may have represented the last specimens of a species nearing extinction in Britain rather than the first records of a new species colonising England. The large-scale anthropogenic disturbance, industrialisation and habitat fragmentation that occurred throughout Britain during the 20th century may have aided the decline of *H. rutilans*, leading to its eventual extinction from mainland England (pers. comm, D. Mann) (Dinn & Sadler, 1999).

The recent evidence of *H. rutilans* recolonising England in Kent and Essex in 2017, 2019 and 2020 may also be linked to increasingly high summer temperatures experienced across Europe and the subsequent range expansion of its host, *P. triangulum*, mirroring the story of *H. nobile*. The range expansion of *P. triangulum* demonstrates how a species that was once limited in distribution, can rapidly increase its range into new territories. The BWARS dataset reveals that *P. triangulum* was recorded 3,009 times between 1830 and 2022, with 1,969 of those records occurring during the last 20 years, representing 65% of the total data for this species in Britain (BWARS national dataset, 2023). *Hedychrum rutilans* may have recolonised mainland England from populations from northern France or the lowland countries. It would not be surprising to observe a significant rise in records for *H. rutilans* northwards throughout England over the next 20 years, as it takes advantage of the increased abundance and distribution of its host.

Colonisations and extinctions of species from Britain may have happened periodically from mainland Europe throughout history as climate and landscapes changed across the continent over time (pers. comm., L. Crowley). Dinn and Sadler (1999) in their analysis of the Holocene entomofauna of the British Isles, found that the interplay between ecological, climatic, and human induced modifications to the landscape of Britain resulted in the loss of 44 species of invertebrates found in mature woodland, wetland, and species-rich grassland. Habitat fragmentation and the increased habitat specificity of many insects is linked to these extinctions, supporting the notion that the species composition of Britain has changed over time as a direct result of dramatic alterations to the landscape and climate over the past 10,000 years.

Though geographically distinct from mainland Europe, the bees and wasps of Great Britain are closely linked to the wider continent. The arrival of *H. nobile* and the recolonisation of England by *H. rutilans* over the last 20 years reflects the integrated nature of aculeates in Britain, with the fortunes of species in northern France, the Channel Islands, Belgium, the Netherlands and Germany. As climatic and environmental pressures impact insect assemblages, there will be species which are unable to rapidly adapt to these new conditions, resulting in a decline in their distribution. This will be particularly pronounced for specialist species associated with a diminishing type of landscape or habitat. Conversely, there will also be opportunistic species which are able to thrive in the new environmental conditions

which become available to them. In the case of *H. nobile*, this wasp has been able to take advantage of the changing landscape and climate of the British Isles, resulting in its dramatic range expansion into central England and beyond over the past 20 years.

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REFERENCES

- Alfken, J. D. 1899. Über das Leben von *Cerceris arenaria* L. und *Cerceris rybiensis* L. *Entomologische Nachrichten* **25**: 106–111.
- Archer, M. E. .2020. *Hedychrum nobile*. (Accessed 20th of February 2023). Available at: <https://www.bwars.com/wasp/chrysididae/elampinae/hedychrum-nobile>.
- Archer, M. E. 2020. *Hedychrum niemelai*. (Accessed 20th of February 2023). Available at: <https://www.bwars.com/wasp/chrysididae/elampinae/hedychrum-niemelai>.
- Archer, M. E. 2020. *Hedychrum rutilans*. (Accessed 20th of February 2023). Available at: <https://www.bwars.com/wasp/chrysididae/elampinae/hedychrum-rutilans>.
- Baldock, D. W. 2010. *The Wasps of Surrey*. Surrey Wildlife Trust. Pirbright.
- Baldock, D. W. & Hawkins, R. D. 2016. *Hedychrum nobile* (Scopoli): A Jewel-Wasp new to Britain and distinct from *Hedychrum niemelai* (Linsenmaier) (Hymenoptera: Chrysididae). *British Journal of Entomology and Natural History* **29**: 197–208.
- Bogusch, P., Luká, J., Šlachta, M., Straka, J., Šima, P., Erhart, J. & Pridal, A. 2021. The spread of *Colletes hederæ* Schmidt & Westrich, 1993 continues – first records of this plasterer bee species from Slovakia and the Czech Republic. *Biodiversity Data Journal* **9**: e66112.
- Bolton, B. & Gauld, I. 1988. *The Hymenoptera*. Oxford University Press.
- Butterfly Conservation 2020. *Comma Butterfly*. (Accessed 20th of February 2023). Available at: <https://www.yorkshirebutterflies.org.uk/yorkshire-species/comma>.
- BWARS, 2023. National Data at 10 km resolution. (Accessed 22nd of February 2023). Available at: <https://www.bwars.com/content/bwars-data-download>.
- Coope, G. R. 1995. Insect faunas in ice age environments: why so little extinction? In Lawton, J. H. & May, R. M. (Eds) *Extinction rates*. Pp 55–74, Oxford University Press, pp. 55–74.
- Dahlbom, A. G. 1845. *Hymenoptera europaea praecipue borealia, formis typicis nonnullis specierum generumve exoticorum propter nexum systematicum associatis, per familias, genera, species et varietates disposita atque descripta* (Vol. 1). Libraria F. Nicolai.
- Dew, R. M., Silva, D. P. & Rehan, S. M. 2019. Range expansion of an already widespread bee under climate change. *Global Ecology and Conservation*, **17**, pe00584.



- Dinnin, M. H. & Sadler, J. P. 1999. 10,000 years of change: The Holocene insect fauna of Britain. *Journal of Quaternary Science* **14**: 545.
- Early, J. 2015. *Nature Conservation Imaging*. www.nature-conservationimaging.com/Pages/nature_conservation_imaging_heathland1_sandpits_parasitecer.php. (Accessed 21st of February 2022).
- Edwards, M. 2014. *Bombus hypnorum* (Accessed 20th of July 2023). Available at: <https://bwars.com/bee/apidae/bombus-hypnorum>.
- Else, G. R. & Roberts, S. P. M. .2019. *Colletes hederæ*. (Accessed 20th of February 2023). Available at: <https://www.bwars.com/bee/colletidae/colletes-hederæ>.
- Else, G. R. 1997. Bees Wasps Ants Recording Society Species profile of *Philanthus triangulum*. (Accessed 20th of February 2023). Available at: [https://www.bwars.com/wasp/crabronidae/philanthinae/philanthus-triangulumtext=This%20wasp%20nests%20in%20both,cell%20\(Lomholdt%2C%201975\)](https://www.bwars.com/wasp/crabronidae/philanthinae/philanthus-triangulumtext=This%20wasp%20nests%20in%20both,cell%20(Lomholdt%2C%201975)).
- Else, G. R. 2012. Bees Wasps Ants Recording Society Species profile of *Cerceris rybyensis*. (Accessed 20th of February 2023. Available at: <https://www.bwars.com/wasp/crabronidae/philanthinae/cerceris-rybyensis>.
- Else, G. R. & Field, J. P. 2012. Bees Wasps Ants Recording Society Species profile of *Cerceris arenaria*. (Accessed 20th of February 2023. Available at: <https://www.bwars.com/wasp/crabronidae/philanthinae/cerceris-arenaria>.
- Falk, S. J. & Lane, S. 1999. *A Survey of the Insects of Sutton Park*. Coventry: Coventry Museums & Galleries Ecology Unit.
- Falk, S. J., Lane, S., Slawson, C. & Bloxham, M. 1996. *A Comparative Study of the Invertebrate Assemblages of Three Staffordshire Heathland Sites*. Coventry: Coventry Museums & Galleries Ecology Unit.
- Falk, S. J. 1991. *A Review of the Threatened Bees, Wasps and Ants of Great Britain*. (Accessed 1st of February 2022). Available at: DOI: 10.13140/RG.2.2.13488.28165.
- Falk, S. J. 2010. The bee and wasp assemblages (Hymenoptera: Aculeata) of some key heathland sites in the West Midlands region. *British Journal of Entomology and Natural History* **23**: 77–98.
- Hamm, A. H. 1930. The biology of the British fossorial wasps of the families Mellinae, Gorytidae, Philanthidae, Oxybelidae and Trypoxylidae. *Transactions of the Royal Entomological Society of London*, **78**(1): 95–131.
- Harvey, P. R. 2002. ACG *Cerceris quinquefasciata*, *Cerceris quadricincta* & *Odynerus simillimus* Project. Report for Aculeate Working Group.
- Hill, J. K., Thomas, C. D., Fox, M. G., Telfer, S. G., Willis., Asher, J. & Huntley, B. 2002. Responses of butterflies to twentieth century climate warming: implications for future ranges. *Proceedings of the Royal Society of London. Series B: Biological Sciences* **269**: 2163–2171. Available at: <https://doi.org/10.1098/rspb.2002.2134>.
- Imbach, P., Fung, E., Hannah, L. & Roehrdanz, P. R. 2017. Coupling of pollination services and coffee suitability under climate change. *Proceedings of the National Academy of Sciences* **114** (59): 10438–10442. Available at: <https://doi.org/10.1073/pnas.1617940114>.
- Inside Ecology. 2023. Invasive Non-native species: The Harlequin Ladybird, *Harmonia axyridis* (Pallas). Accessed 16th of February 2023). Available at: <https://insideecology.com/2017/12/06/invasive-non-native-species-uk-harlequin-ladybird/:text=The%20ladybird%20arrive-d%20in%20the.first%20four%20years%20of%20establishment..>
- Kimsey, L., & Bohart, R. 1991. *The Chrysidid Wasps of the World*. Oxford Press, New York, 652 pp
- Linsenmaier, W. 1959. Revision der Familie Chrysididae (Hymenoptera) mit besonderer Berücksichtigung der europäischen Spezies. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* **32**: 1–232.
- Majerus, M., Strawson, V. & Roy, H. 2006. The potential impacts of the arrival of the harlequin ladybird, *Harmonia axyridis* (Pallas) (Coleoptera : Coccinellidae), in Britain. *Ecological Entomology* **31**: 207–215.



- Met Office 2022. 2022. Provisionally the Warmest Year on Record for UK. (Accessed 20th January 2023). Available at: <https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/2022-provisionally-warmest-year-on-record-for-uk>.
- Miličić, M., Vujić, A. & Cardoso, P. 2018. Effects of climate change on the distribution of hoverfly species (Diptera: Syrphidae) in Southeast Europe. *Biodiversity and Conservation* **27**: 1173–1187.
- Morgan, H. J. 1984. *Cuckoo-wasps*. (Hymenoptera, Chrysididae). Handbooks for the Identification of British Insects **6**: 1–37.
- Morice, F. D. 1889. Rare Aculeate Hymenoptera in 1899. *Entomologists Monthly Magazine* **25**: 435–455.
- NBN Atlas. 2021. *Pyrrhocoris apterus*. (Accessed 1st of February 2023).
- Pateman, R. M., Hill, Roy, D. B., Fox, R. & Thomas, C. D. 2012. Temperature-dependent alterations in host use drive rapid range expansion in a butterfly. *Science* **336**: 1028.
- Paukkunen, J., Berg, A., Soon, V., Ødegaard, F. & Rosa, P. 2015. An illustrated key to the cuckoo wasps (Hymenoptera, Chrysididae) of the Nordic and Baltic countries, with description of a new species. *ZooKeys* **548**: 1–116.
- Paukkunen, J., Rosa, P., Soon, V., Johansson, N. & Paard, F. 2014. Faunistic review of the cuckoo wasps of Fennoscandia, Denmark and the Baltic countries (Hymenoptera: Chrysididae). *Zootaxa* **3864**: 1–67.
- Pendleton, T. 2022. *Redychrum nobile*. (Accessed 20th of February 2023. Available at: <http://www.eakringbirds.com/eakringbirds2/insectinfocushedychrumnobile.htm>).
- Platts, P. J., Mason, S. C., Palmer, G., Hill, J. K., Oliver, T. H., Powney, G. D., Fox, R. & Thomas, C. D. 2019. Habitat availability explains variation in climate-driven range shifts across multiple taxonomic groups. *Scientific Reports*, 9(1), p. 15039. Available at: <https://doi.org/10.1038/s41598-019-51582-2>.
- Polidori, C., Bevacqua, S. & Andrietti, F. 2010. Do digger wasps time their provisioning activity to avoid cuckoo wasps (Hymenoptera: Crabronidae and Chrysididae)? *Acta Ethologica* **13**: 11–21.
- Rahimi, E., Barghjelveh, S. & Dong, P. 2021. Estimating potential range shift of some wild bees in response to climate change scenarios in northwestern regions of Iran. *Journal of Ecology and Environment* **45**: Article 14.
- Rosa, P. & Soon, V. 2012. *Fauna Europaea: Chrysididae*. In: Mitroiu, M.-D. (Ed.) *Fauna Europaea: Hymenoptera*, version 2.5. <http://www.faunaeur.org> (accessed 1 April 2015).
- Rosa, P., Wei, N. S. & Xu, Z. F. 2014. An annotated checklist of the chrysidid wasps (Hymenoptera, Chrysididae) from China. *ZooKeys* **455**: 1–128.
- Saunders, E., Barrett, C. G., Champion, G. C., Douglas, J. W., Fowler, W. W. & McLachlan, R. 1901. *The Entomologists Monthly Magazine*. 2nd Series Volume 11.
- Shirt, D. B. 1987. *Red data book of British insects*. (Accessed 1st of February 2023). Available at: <https://www.brc.ac.uk/biblio/british-red-data-books-2-insects>.
- Shuckard, W. E. 1837. Essay on the indigenous fossorial Hymenoptera: comprising a description of all the British species of burrowing sand wasps. *The Entomologists Magazine*. (Accessed 1st of April 2023). Available at: <https://www.biodiversitylibrary.org/item/49790/page/7?mode/lup>
- Shuckard, W. E. 1837. Description of the genera and species of the British Chrysididae. *Entomologist's Magazine* **4**: 156–177.