Hoverflies specialised to veteran trees in Europe

Conservation action plan 2023–2030

Orange-horned Wasp Fly (*Sphiximorpha petronillae*), Red-legged Leafwalker (*Chalcosyrphus pannonicus*), Royal Wasp Fly (*Primocerioides regale*), Golden Forest Fly (*Brachypalpus chrysites*), Jacobson's Leafwalker (*Chalcosyrphus jacobsoni*), Black-legged Leafwalker (*Chalcosyrphus nigripes*)

Ante Vujić, Marija Miličić, Marina Janković Milosavljević, Jeroen van Steenis, Craig Macadam, Julia Raser, Axel Hochkirch

European Commission
IUCN
SSC Species Survival Commission
ICC IUCN SSC Invertebrate Conservation Committee
IUCN SSC Hoverfly Specialist Group
buglife

Hoverflies specialised to veteran trees in Europe

Conservation action plan 2023–2030

Orange-horned Wasp Fly (*Sphiximorpha petronillae*), Red-legged Leafwalker (*Chalcosyrphus pannonicus*), Royal Wasp Fly (*Primocerioides regale*), Golden Forest Fly (*Brachypalpus chrysites*), Jacobson's Leafwalker (*Chalcosyrphus jacobsoni*), Black-legged Leafwalker (*Chalcosyrphus nigripes*)

Ante Vujić[1,2,3,] Marija Miličić[2,3,] Marina Janković Milosavljević[2,3], Jeroen van Steenis[4], Craig Macadam[5], Julia Raser[6], Axel Hochkirch[2,6]

1. IUCN SSC Invertebrate Conservation Committee
2. IUCN SSC Hoverfly Specialist Group
3. University of Novi Sad
4. Syrphidae in Trees / Syrphidae Foundation
5. Buglife
6. Trier University

PDF ISBN: 978-92-68-01061-7 doi: 10.2779/414475 KH-07-23-143-EN-N

Getting in touch with the EU
In person
All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en
On the phone or by email
Europe Direct is a service that answers your questions about the European Union. You can contact this service:
– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
– at the following standard number: +32 22999696 or
– by email via: https://europa.eu/european-union/contact_en

Finding information about the EU
Online
Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en
EU publications
You can download or order free and priced EU publications at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/europeanunion/contact_en).

EU law and related documents
For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EURLex at: http://eur-lex.europa.eu

Open data from the EU
The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, both for commercial and non-commercial purposes.

Citation Information
This publication has been drafted by IUCN within the framework of the contract No 07.0202/2020/839411/SER/ENV.0.2 'Action Plans for conservation of threatened pollinator species in the EU'. The information and views set out in this publication do not necessarily reflect the official opinion of the Commission, or IUCN. The Commission does not guarantee the accuracy of the data included in this publication. Neither the Commission nor IUCN or any person acting on the Commission's behalf, including any authors or contributors of the publication themselves, may be held responsible for the use which may be made of the information contained therein. The designation of geographical entities in this book, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of the European Commission, IUCN or other participating organisations concerning the legal status of any country, territory or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. The views expressed in this publication do not necessarily reflect those of the European Commission, IUCN or other participating organisations. Reproduction is authorised provided the source is acknowledged.

Authors: Vujić, A., Miličić, M., Janković Milosavljević, M., van Steenis, J., Macadam, C., Wilkins, V., Raser, J. and Hochkirch, A.

Design and layout: Imre Sebestyén jr. / UNITgraphics.com

Picture credits on cover page: Female *Sphiximorpha petronillae* showing egg laying behaviour on an Oak tree in Novi Sad, Serbia © J. van Steenis, 2019

Recommended citation: Vujić, A., Miličić, M., Janković Milosavljević, M., van Steenis, J., Macadam, C., Wilkins, V., Raser, J., & Hochkirch, A (2023). *Hoverflies specialised to veteran trees in Europe – Conservation Action Plan 2023–2030*. Publication prepared for the European Commission within the framework of the contract No 07.0202/2020/839411/SER/ENV.0.2

European Commission

Contents

Introduction

This document was drafted within the framework of an EU funded project 'Action Plans for conservation of threatened pollinator species in the EU', launched by the European Commission in the context of the implementation of the EU Pollinators Initiative. The objective of the project was to develop three EU Species Action Plans for the most threatened pollinator species, by building on existing experience and using the European Red List as a reference. The methodology to develop theseactions plans is based on the *Guidelines for Species Conservation Planning* (IUCN SSC, 2017), developed by the former IUCN SSC Conservation Planning Sub-Committee, as well as the *CPSG Conservation Planning Principles and Steps* (CPSG, 2020), developed by IUCN SSC Conservation Planning Specialist Group (CPSG).

Over the course of the project, the experts shortlisted 15 species candidates for an action plan. This list has been verified during a dedicated workshop on 18 June 2021. After the validation of the selection, three conservation action plans were selected, including one for hoverflies specialised to veteran trees.

Background on hoverflies specialised to veteran trees

Hoverflies are a species-rich family of Diptera with more than 6,000 described species globally (Pape *et al.,* 2011), and around 900 species recorded in Europe. They fulfil important roles and functions in ecosystems as pollinators of flowering plants, nutrient recyclers, and predators of plant pests (Rotheray & Gilbert, 2011; Vujić *et al.,* 2021). Furthermore, hoverflies provide qualitative information on forest and wetland habitats and, overall, can make an important contribution to the assessment and conservation of nature and habitats (Speight, 1989; van Steenis, 2016). Almost half of all hoverfly species are saprophages (organisms feeding on dead or decaying organic matter), and these include saproxylic species that depend on living and dead wood (van Steenis, 2023), conveniently called tree related microhabitats (TreMs). TreMs and their associated species assemblages are a rich source of biodiversity and are fundamental to forest function, but mainly due to poor forestry management, many saproxylic species are threatened, from vulnerable (VU) to critically endangered (CR) and even regionally extinct (RE). Saproxylic hoverflies have been used as indicators of woodland quality (Ricarte *et al.,* 2009; Speight, 1989) and have been suggested as indicators of climate change (Rotheray & Gilbert, 2011).

Knowledge of many European saproxylic hoverfly species still remains poor. Some important aspects of their biology and ecology, distribution and population trends are still unknown. Published data show that major breeding sites for saproxylic hoverflies are tree holes, exudations of tree sap and wet decaying wood (Rotheray & Stuke, 1998; van Steenis *et al.,* 2020), but the extent to which individual species are confined to such breeding sites and the level of specificity to tree species is uncertain for the majority of species. Such data are often critical for evaluating status, investigating ecology, and devising conservation strategies (Rotheray & Macgowan, 2000).

This document provides the basis for a Conservation Action Plan for threatened European hoverfly species which are specialised on veteran trees or wet decaying wood, including the Orange-horned Wasp Fly (*Sphiximorpha petronillae* Rondani, 1850), the Red-legged Leafwalker (*Chalcosyrphus pannonicus* Oldenberg, 1916), the Royal Wasp Fly (*Primocerioides regale* Violovitsch, 1985), the Golden Forest Fly (*Brachypalpus chrysites* Egger, 1859), Jacobson's Leafwalker (*Chalcosyrphus jacobsoni* Stackelberg, 1921) and

the Black-legged Leafwalker (*Chalcosyrphus nigripes* Zetterstedt, 1838), five of which are classified as Endangered on the European Red List and one as Vulnerable. Veteran trees are defined as "trees with habitat features such as wounds or decay" (Woodland Trust, 2008). Veterantrees are usually old but can also be quite young with developed sap-runs caused by wounds or diseases. They provide numerous different TreMs (Larrieu *et al.,* 2017) for hoverflies, including moist decaying wood, sap-runs, rot holes, cracks, rotting heartwood, etc. (van Steenis, 2023).

The target hoverfly species of this plan are considered umbrella species for the conservation of veteran tree communities or those requiring decaying dead wood. For each of these species, a comprehensive status review of the known information on taxonomy and systematics, biology and ecology, functions and values, historical and current distribution and demography, habitat and resource availability and threats is provided. This review provides the information necessary to identify major knowledge gaps and necessary conservation action for these hoverfly species. This information was used to develop a Species Action Plan for threatened European hoverfly species specialised on veteran trees and decaying wood. While the target species are rare and urgently require conservation action to promote their survival, the proposed action will also benefit many other species which require veteran trees and decaying moist wood.

Status review

Orange-horned Wasp Fly, *Sphiximorpha petronillae* (Rondani, 1850)

Species description

Systematics / taxonomy

Sphiximorpha petronillae Rondani, 1850 (Figures 1 and 2) is a saproxylic species belonging to the family Syrphidae (Aracil *et al.*, 2021b). It is also known under the name *Cerioides petronillae* (see Sack, 1932), but the genus *Cerioides* was subsequently synonymised with *Sphiximorpha*.

Figure 1: A female of Sphiximorpha petronillae. (Picture: F. Mason (Burgio et al., 2015))

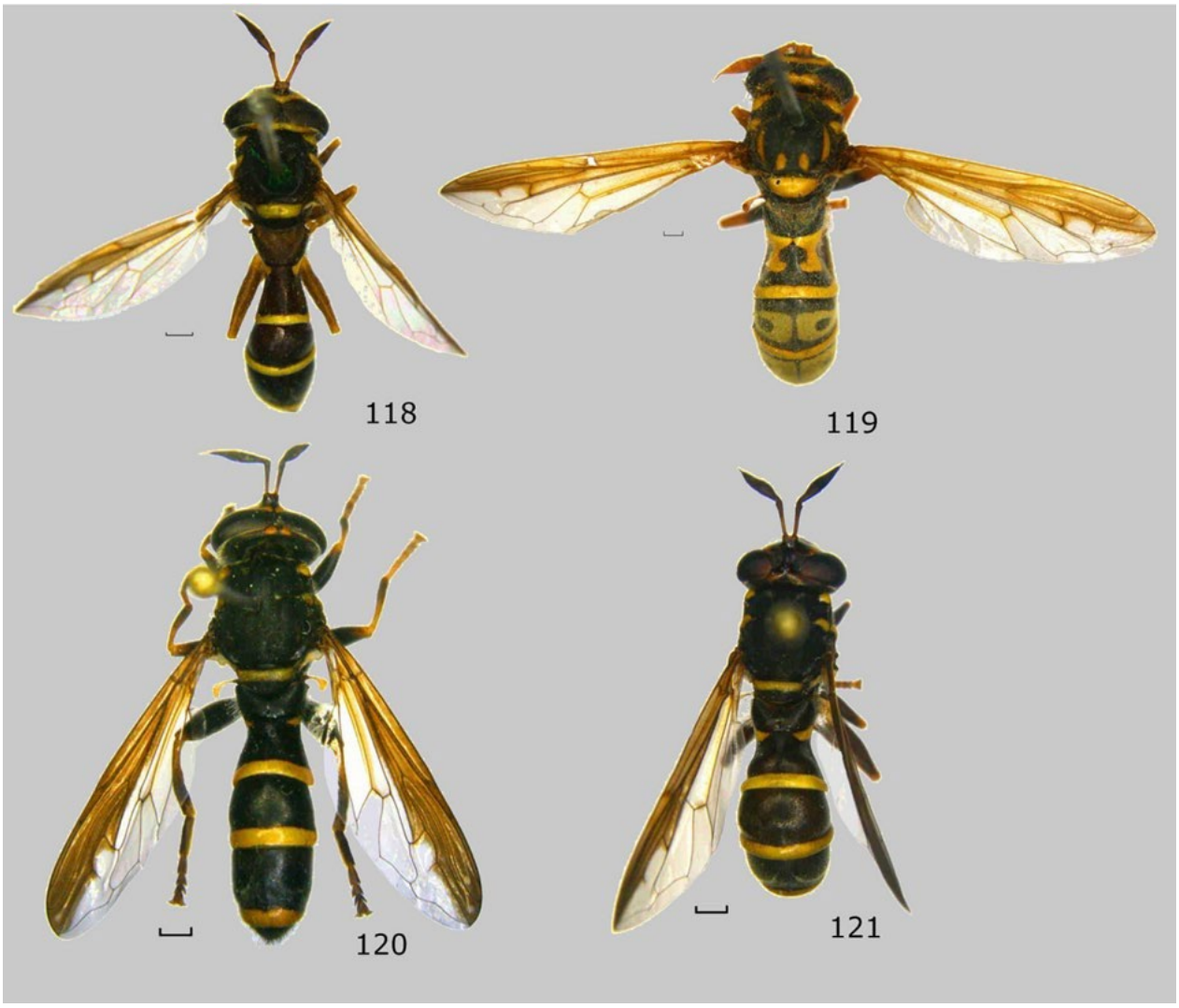

Figure 2: Adults of Sphiximorpha species. 118 Male of Sphiximorpha euprosopa, holotype 119 Female of Sphiximorpha petronillae, lectotype 120 Male of Sphiximorpha subsessilis from the Netherlands 121 Female of Sphiximorpha subsessilis from Greece. The scale bar represents 1 mm. (Picture: van Steenis et al., 2016)

The females of *Sphiximorpha petronillae* (Figure 1) have a body size of 11.3–15.3 mm and a wing length of 9.0–12.6 mm (van Steenis *et al.,* 2016). The head is 1.6–1.7 times wider than the face and, like the abdomen, has a characteristic yellow-black colour pattern (van Steenis *et al.,* 2016). The antennae are orange, and the arista is white, covered with hairs. The male has not been scientifically described (van Steenis *et al.,* 2016), but it was recently collected in Serbia near Novi Sad (van Steenis *et al.,* 2019).

Biology and ecology

The habitat of *Sphiximorpha petronillae* is veteran thermophilous *Quercus cerris* forest, *Quercus cerris/Quercus frainetto* forest and humid *Castanea*, *Quercus* and *Laurus* forest (Speight, 2020; van Steenis *et al.,* 2016). The species was observed on trees co-occurring with the saproxylic ant *Liometopum microcephalum* (European Velvety Tree Ant, Formicidae). This ant typically inhabits trees with hollow trunks, which may be suitable habitats for the eggs of *S. petronillae* (Speight, 2020). The females of the hoverfly were seen laying eggs in the bark of old, living *Quercus cerris* colonised by this ant (van Steenis *et al.,* 2019). Waiting for the females, the males were observed motionless at the height of one to five metres from the ground on the trunk of the oak on calm and sunny days (Speight, 2020).

Aracil *et al*. (2021b) suggest that *Sphiximorpha petronillae* is rarely found without the ant presence, naming *L. microcephalum* as an indicator for the occurrence of the hoverfly. Besides the European Velvety Tree Ant, the hoverfly might be associated with aphid colonies. In addition, *Polistes dominula* (European Paper Wasp, Vespidae) may also be present on trees with *Sphiximorpha petronillae*. In their fieldwork, van Steenis *et al*. (2019) found females of *S. petronillae* mimicking *P. dominula* with orange antennae and long hind legs hanging down (Figure 3).

The flight period is from April to May. Flowers of *Euphorbia*, *Pyracantha coccinea* and *Smyrnium* have been observed to be visited by adults (Speight, 2020; van Steenis *et al.,* 2016).

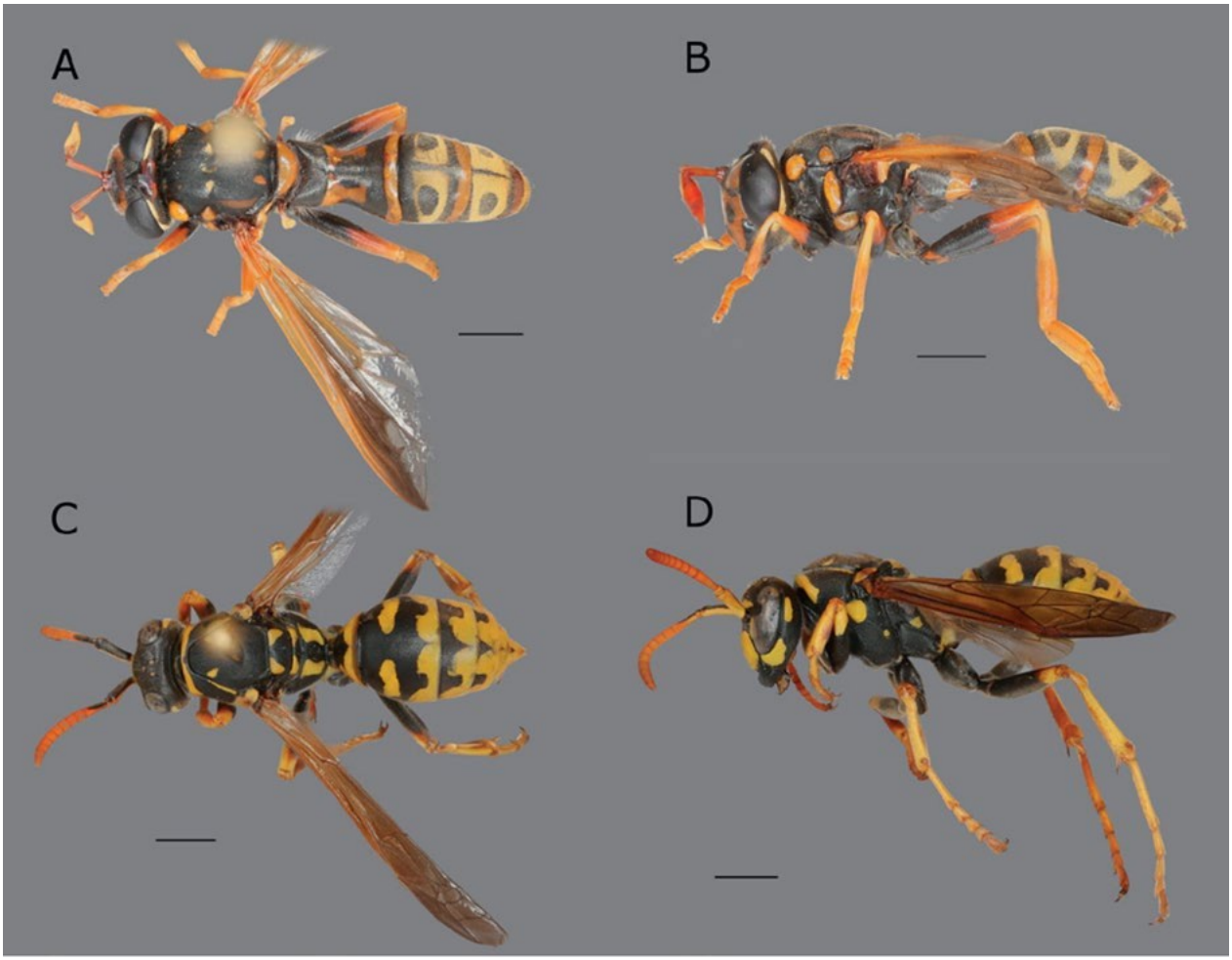

Figure 3: Female adults of Sphiximorpha petronillae (A dorsal view, B lateral view) and Polistes dominula (C dorsal view, D lateral view). The scale bar represents 2 mm. (Picture: van Steenis et al., 2019)

Functions and values

Like other saproxylic hoverflies, *S. petronillae* is an indicator of forest quality. Historically abundant, it is now one of the rarest hoverfly species in Europe. Its connection with oak forests which are in general decline across Europe points to potential further decline of *S. petronillae*, which is why special effortsshould be made to preserve it. Due to its conspicuous appearance, it could be used as a flagship species when producing promotional material aiming to raise awareness of the significance of saproxylic hoverflies.

Historical distribution

The historical distribution of S. *petronillae* was probably related to *Quercus* forests in the South and some parts of Central Europe (Figure 4). It is likely that its historical distribution encompassed all areas with this habitat type and that the abundance of this species was much higher than at present. Today, oak forests are in general decline all across Europe (Sohar *et al.,* 2014) and most of the remaining habitat patches are small and scattered, limiting their carrying capacity. Some forests have been transformed into agricultural land, while in others forestry practices changed with removal of old and partly damaged trees. This has caused destruction, habitat size reduction and fragmentation of these forestsand microhabitats for saproxylic species, which has influenced the current distributional patterns of *S. petronillae*.

Figure 4: Records of Sphiximorpha petronillae from Ante Vujić, Aracil et al. (2021b), IUCN Red List, Observation.org, Sander Bot and van Steenis et al. (2019); black dots: old and undated records; red dots: recent records (2019–2020).

Current distribution and demography

Sphiximorpha petronillae is an endemic European species with an area of occupancy (AOO) of 32 km² and an extent of occurrence (EOO) of 355,000 km² (Aracil *et al.,* 2021b). It

is one of the rarest hoverfly species in Europe (Speight, 2020; van Steenis *et al.,* 2016; Vujić *et al.,* 2020). In the last 150 years, a total of four female individuals have been documented from Italy and Montenegro. Of these, three specimens were found in Italy (last record from 2003) and one in Montenegro (from 2005). Further occurrences are known from north-eastern Greece at a Natura 2000 site, Dadia National Park (Figure 4, with several records in the last two decades). The most recent findings stem from a natural area in Novi Sad, Serbia (van Steenis *et al.,* 2019). Aracil *et al*. (2021b) predict the extinction of the Serbian population in 20–30 years as soon as the trees in the refuge are removed by urban management measures.

Habitat and resource assessment

Van Steenis *et al*. (2019) found four individuals of *Sphiximorpha petronillae* in Kamenički Park in Novi Sad (Serbia). This park is protected as a Nature Monument and classified as a 'saproxylic insect and bird park' (van Steenis *et al.,* 2019). In total, Kamenički Park covers an area of 33 ha, but *S. petronillae* was only found on one *Quercus pubescens* tree (planted in 1805, Figure 5) with sap-runs and rot holes as tree-related microhabitats for saproxylic species. The oak is located in a higher part of the park on a mown meadow and close to *Prunus avium* and some destroyed *Aesculus* individuals. Eastwards from the refuge is a cultivated pine forest, but according to van Steenis *et al*. (2019) it is not considered to be of important ecological significance. Instead, the authors recommend converting the coniferous forest into a deciduous forest with "*Quercus cerris*, *Q. pubescens*, *Aesculus hippocastanum, Tilia tomentosa* with some flowering shrubs and trees like *Crataegus* spp. and *Prunus* spp.".

Figure 5: Quercus pubescens with broken off branches in Kamenički Park in Serbia representing the habitat of Sphiximorpha petronillae. (Picture: van Steenis et al., 2019)

Threat analysis

According to Aracil *et al*. (2021b), habitat loss is the main threat to the species, which is mainly defined by the disappearance of veteran trees and decaying wood. In particular, the saproxylic larva depends on old trees, which is why it is endangered by clearings (e.g. for tourism), replacement of old growth forests by plantations and wildfires (Aracil *et al.,* 2021b). In addition, the authors highlight climate change through temperature fluctuations and hydrological factors as an additional threat. All these threats are ongoing and act at the ecosystem level, causing conversion and degradation of ecosystems, while at the species level they can cause extinction. However, the intensity of threats remains unknown, as well as their scope.

Table 1. Threat analysis for Sphiximorpha petronillae, based on Aracil et al. (2021b).

Threat	Priority	Timing	Knowledge	Presumed current impact
Logging and wood harvesting	1	Ongoing	Medium	High
Fire and fire suppression	2	Ongoing	Medium	High
Tourism and recreation areas	3	Ongoing	Low	Medium
Climate change (temperature fluctuations, hydrological factors, habitat shifts and alterations)	4	Ongoing	Low	Low

Red-legged Leafwalker, *Chalcosyrphus pannonicus* (Oldenberg, 1916)

Species description

Systematics / taxonomy

Chalcosyrphus pannonicus (Oldenberg, 1916) is a medium-sized to large saproxylic hoverfly (Figures 6–8) (Mielczarek, 2014). The genus *Chalcosyrphus* Curran, 1925 consists of twelve known species in Europe (Mielczarek, 2014). The basionym is *Zelima pannonica* Oldenberg, 1916 (Pennards *et al.*, 2021b). Like many hoverflies, *C. pannonicus* mimics species of the Hymenopteran superfamily Ichneumonoidea.

Figure 6: Chalcosyrphus pannonicus from the Greek Rhodope Mountains. (Picture: Ssymank, 2012)


Figures 7 & 8: Left: A male of Chalcosyrphus pannonicus from Poland. Right: A male of Chalcosyrphus pannonicus from Slovakia. (Picture: Mielczarek, 2014)

Biology and ecology

The flight period of *Chalcosyrphus pannonicus* lasts from June to July (Pennards *et al.,* 2021b; Speight, 2020). Its preferred environments are 'swamp' (Drensky, 1934), and flushes and areas beside streams in mesophilous *Picea abies* forests (Ssymank, 2012). It is found on flowers of *Cirsium* sp. (Mielczarek, 2014), *Verbascum densiflorum* (Ssymank, 2012) and *Pastinaca sativa* (Vujić *et al.,* 2021). Adults of the genus *Chalcosyrphus* are known to visit flowers infrequently and the larvae inhabit tree trunks (Mielczarek, 2014). The larvae feed on microorganisms found under the bark of dead or diseased usually deciduous trees (Soszyńska-Maj *et al.,* 2009), but the larvae of *C. pannonicus* have never been documented.

Functions and values

The functions of this species are little understood. Generally, knowledge of this species is scarce, except the fact that it is extremely rare. Even before the assessments conducted for the IUCN Red List of hoverflies, this species was already considered threatened at the European level. Thus, efforts not only for its preservation, but also for obtaining further knowledge about this species are needed.

Historical distribution

It is considered that *C. pannonicus* had a wider distribution and was much more abundant in the past (Figure 9). However, its current distribution is reduced as a result of forest management practices in southern and parts of central Europe. Inadequate practices have had effects in two ways: suitable habitats have become small and patchy, causing the population to become severely fragmented, and as the subpopulations have become small and isolated, they have faced a reduced probability of recolonisation. Secondly, practices included extraction of old, rotten and fallen trees, where it is assumed that larvae of *C. pannonicus* develop, thus directly destroying larval microhabitat of this species. Mire habitat, found to be suitable for this species, is also being massively destroyed, which has caused the reduction ofrange in this species.

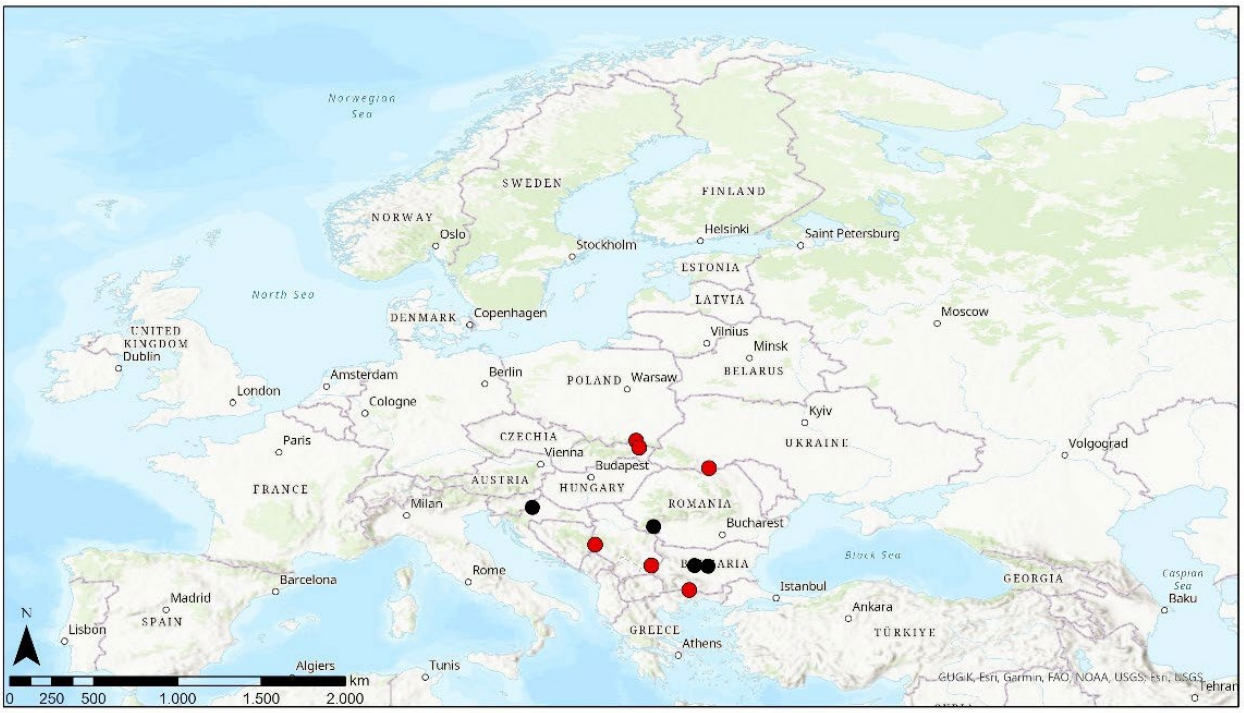

Figure 9: Records of Chalcosyrphus pannonicus from GBIF, Langhoffer, Mielczarek (2014), Miroslav Bartak Collection, Oldenberg (1916), Pennards et al. (2021b) Ssymank (2012) and Vujić et al. (2021); black dots: old and undated records; red dots: recent records (2007–2020).

Current distribution and demography

In Europe, *C. pannonicus* is one of the rarest species of its genus with an estimated extent of occurrence (EOO) of 246,000 km² and an estimated area of occupancy (AOO) of 68 km². The small AOO is caused by the limited and fragmented habitat of *Chalcosyrphus pannonicus* (Pennards *et al.,* 2021b). In Europe, it occurs in Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Poland, Romania, Serbia, Slovakia and Ukraine (Figure 9; Mielczarek, 2014; Pennards *et al.,* 2021b). With these occurrences, *C. pannonicus* shows the most southern distribution of the genus *Chalcosyrphus* in Europe (Mielczarek, 2014). Overall, the population is declining in Europe (Pennards *et al.,* 2021b).

Habitat and resource assessment

Ssymank (2012) describes *Chalcosyrphus pannonicus* as a "species linked to dead wood" and first discovered it in Greece in the Rhodope Mountains in Elatia (2007 and 2008), when a female showed up on a flower of *Verbascum densiflorum* at an altitude of 1,600 m. The surroundings were characterised by a high occurrence of *Verbascum* species, a place storing timber and the edge of a mesophilous *Picea abies* forest (Ssymank, 2012). Two further individuals were discovered in Malaise traps in the same area. Both sites were at an altitude of about 1,500 m and surrounded by a *Picea abies* forest. The first site was shaped by a transition mire and the second by a small stream with moistand herbaceous plant species (Ssymank, 2012). *C. pannonicus* also occurs in Slovakia and Poland in the Carpathian Mountains. There, individuals were found at altitudes of 530 m and 200 m close to the deciduous forest (Mielczarek, 2014).

Threat analysis

Pennards *et al.* (2021b) mention human impact through deforestation, drainage or logging as threats. The mire habitat of the species is also threatened and substantially reduced in Europe (Pennards *et al.*, 2021b). These threats are ongoing and act at the ecosystem level, causing conversion and degradation of ecosystems, while at the species level can cause mortality. However, the intensity of threats remains unknown, as well as their scope.

Table 2. Threat analysis for Chalcosyrphus pannonicus, based on Pennards et al. (2021b).

Threat	Priority	Timing	Knowledge	Presumed current impact
Logging and wood harvesting	1	Ongoing	Medium	High
Deforestation	2	Ongoing	Low	Medium
Commercial and industrial areas	3	Ongoing	Low	Low
Abstraction of surface water	4	Ongoing	Low	Medium

Royal Wasp Fly, *Primocerioides regale* (Violovitsch, 1985)

Species description

Systematics / taxonomy

Primocerioides regale Violovitsch, 1985 is another saproxylic hoverfly species (Aracil *et al.,* 2021a). *Sphiximorpha hiemalis* is a synonym of *P. regale* (van Steenis *et al.,* 2016). The species is a European endemic, but the genus has a very scattered distribution with two further species occurring outside Europe. *P. petri* (Hervé-Bazin, 1914) is known from the Russian Far East and Japan, while *P. yoshikawai* (Sasakawa, 1960) is found in the Oriental part of China (Speight, 2020).

The males are larger (body length: 14.8–15.2 mm; wing length: 10.5 mm) than the females (body length: 13.9 mm; wing length: 10.4 mm) (Ricarte *et al.,* 2012; van Steenis *et al.,* 2016). Ricarte *et al*. (2012) describe the body hair of males as morphologically particularly striking. *P. regale*, like related species of the genus *Sphiximorpha*, mimics wasps of the family Eumenidae (Vujić *et al.,* 2020).

Biology and ecology

The habitat of *Primocerioides regale* consists of thermophilous *Carpinus*, *Fraxinus* and *Quercus* forests (more precisely: *Q. frainetto*, *Q. pubescens* and *Q. cerris*) along streams, gallery forests of *Carpinus* and *Quercus* in *Pinus brutia* forests and olive orchards (Speight, 2020; van Steenis *et al.,* 2016; van Steenis *et al.,* 2019; Vujić *et al.,* 2020). Based on Speight (2020), *P. regale* visits flowers of *Pyrus spinosa* and *Cornus mas*. Males were observed during the evening (from 17:30 – 18:30) feeding on flowers and searching for females on *Pyrus* (Speight, 2020; Vujić *et al.,* 2020). In addition, the males were seen sitting on bare branches of *Cornus* (Speight, 2020). The flight period of the adults lasts from the end of February to the beginning of May. The larval and pupal stages of the species remain unknown (Aracil *et al.,* 2021a; Speight, 2020).

Functions and values

Primocerioides regale is one of the rarest European hoverfly species. This species is found in only a few localities in Serbia, Greece and Cyprus – localities with good stands of old-growth thermophilous *Quercus* forest, but also with stretches of gallery forest along streams. As it is very unlikely that this species occurs elsewhere in Europe, it can be considered as a good indicator species for detecting changes in these particular habitat types.

Historical distribution

Primocerioides regale was first discovered in Belgrade (Serbia) in 1985 and described based on a male specimen. The holotype was until recently the only known individual of the species from Serbia, but it was rediscovered in 2019 at the type locality in Belgrade Memorial Park of Jajinci (Figure 10; Aracil *et al.,* 2021a; van Steenis *et al.,* 2019; Vujić *et al.,* 2020).

Current distribution and demography

Primocerioides regale is very rare and known to occur in Serbia, north-eastern Greece and southern Cyprus (Figure 10). It was rediscovered in Belgrade in 2019 by Miroslav Mareš (van Steenis *et al.,* 2019). In Greece, the species was found at four localities in Dadia National Park in the Eastern Rodopi Mountains (Aracil *et al.,* 2021a). Ricarte *et al.* (2012) found one male on the Aegean Island of Lesvos in 2006 (described as *Sphiximorpha hiemalis*). There is only one older record from Cyprus, where the species now might be extinct (van Eck, pers. comm., 2019; Aracil *et al.,* 2021a). Based on known localities, the estimated area of occupancy (AOO) is 24 km² and the extent of occurrence (EOO) is 51,900 km² (Aracil *et al.,* 2021a).

Figure 10: Records of Primocerioides regale from Observation.org., Ricarte et al. (2012) and van Steenis et al. (2019); black dots: old and undated records; red dots: recent records (2012–2020).

Habitat and resource assessment

Primocerioides regale depends, like other saproxylic species, on forests with veteran trees (Vujić *et al.,* 2020). In Belgrade, it was found on a veteran *Fagus* tree in the Memorial Park Jajinci (M. Mareš, pers. comm., 2022). Vujić *et al.* (2020) state that the hoverfly is highly endangered due to habitat destruction in its entire European range.

Threat analysis

The species is threatened by the loss and destruction of its habitat (Vujić *et al.,* 2020). This process is mainly driven by unsustainable forest management, the removal of dead wood and the cultivation of monocultures (Aracil *et al.,* 2021a). In addition, forest fires, hydrological changes and other anthropogenic impacts (such as habitat destruction for urbanisation) cause a decline in the habitat of *P. regale* (Aracil *et al.,* 2021a). Threats mentioned are ongoing and affect the species at the ecosystem level, causing conversion and degradation of ecosystems, as well as at the species level, both directly (impacting mortality) and indirectly through various effects. However, the intensity of threats remains unknown, as well as their scope.

Table 3. Threat analysis for Primocerioides regale, based on Aracil et al. (2021a).

Threat	Priority	Timing	Knowledge	Presumed current impact
Unsustainable forest management, removal of dead wood	1	Ongoing	Medium	High
Cultivation of monoculture	2	Ongoing	Medium	Medium
Increasing fire frequency/ intensity	3	Ongoing	Medium	Medium
Climate change: habitat shifts and alterations	4	Ongoing	Low	Medium
Housing and urban areas	5	Ongoing	Low	Low

Golden Forest Fly, *Brachypalpus chrysites* (Egger, 1859)

Species description

Systematics / taxonomy

The Golden Forest Fly, *Brachypalpus chrysites* Egger, 1859 is also a saproxylic hoverfly in Europe (Figure 11; Pennards *et al.,* 2021a). In Germany, the species is known under the vernacular name 'Goldgelbe Mulmschwebfliege' (Pennards *et al.,* 2021a). According to Speight (2020), there are three species of the genus *Brachypalpus* in Europe: *B. chrysites*, *B. laphriformis* and *B. valgus*. A fourth species was recently recognised in Serbia, but is still undescribed (van Steenis *et al.,* 2019). There is no doubt that after its description, this new species is highly threatened and will probably be assessed as Critically Endangered in the near future based on a single known location in this recently discovered hot-spot of saproxylic species in Kamenički Park in Serbia.

Figure 11: Brachypalpus chrysites. (Photo by Ronny Köhler via Observation.org)

Biology and ecology

Speight (2020) describes conifer *Abies/Picea* forests with overmature trees as the preferred habitat of *Brachypalpus chrysites*. Its occurrence ranges from the upper *Fagus* border to the *Larix/Pinus mugo* zone. The hoverfly has been observed to visit flowers of *Centaurea, Crataegus, Crocus, Eriophorum vaginatum, Helleborus niger, Petasites albus, Ranunculus, Salix, Sorbus aucuparia* and *Tussilago* (Speight, 2020). Furthermore, it has been seen on felled trunks of *Larix* and *Picea*. *Brachypalpus chrysites* has been observed flying over low-growing vegetation at the edges of forest clearings. In general, the species flies rather slowly and mimics *Bomus* or *Laphria flava* (Moertelmaier, pers. comm.; Speight, 2020).

Adults are active from April to June and until July at higher altitudes (Pennards *et al.,* 2021a; Speight, 2020). Schmid and Moertelmaier (2007) captured females of *B. chrysites*, observed oviposition inthe laboratory and followed larval development over 6.5 months. The larvae hatched 4–5 days after the oviposition of about 30 eggs. The larva has a length of 18 mm and is whitish coloured (Schmid &Moertelmaier, 2007).

Functions and values

This species is found in mountainous parts of central and south-eastern Europe. It is connected with open *Abies*/*Picea* forest with overmature trees. There is a projected future decline in the quality of its habitat, due to anthropogenic activities and climate change. This is consistent with a decrease of the species range and fragmentation of species population. Therefore, *B. chrysites* can be considered as an indicator species of the status and health of mountainous conifer forest.

Historical distribution

Unlike most of the species specialising on veteran trees which are affiliated predominantly with *Quercus* forests, *B. chrysites* is associated with higher altitudes and *Fagus* and *Picea* forests. These forests have suffered fewer negative impacts compared to lowland forests, but modern forestry practices still impact on its populations and distribution. Therefore, it is likely that the species formerly had a wider distribution (Figure 12).

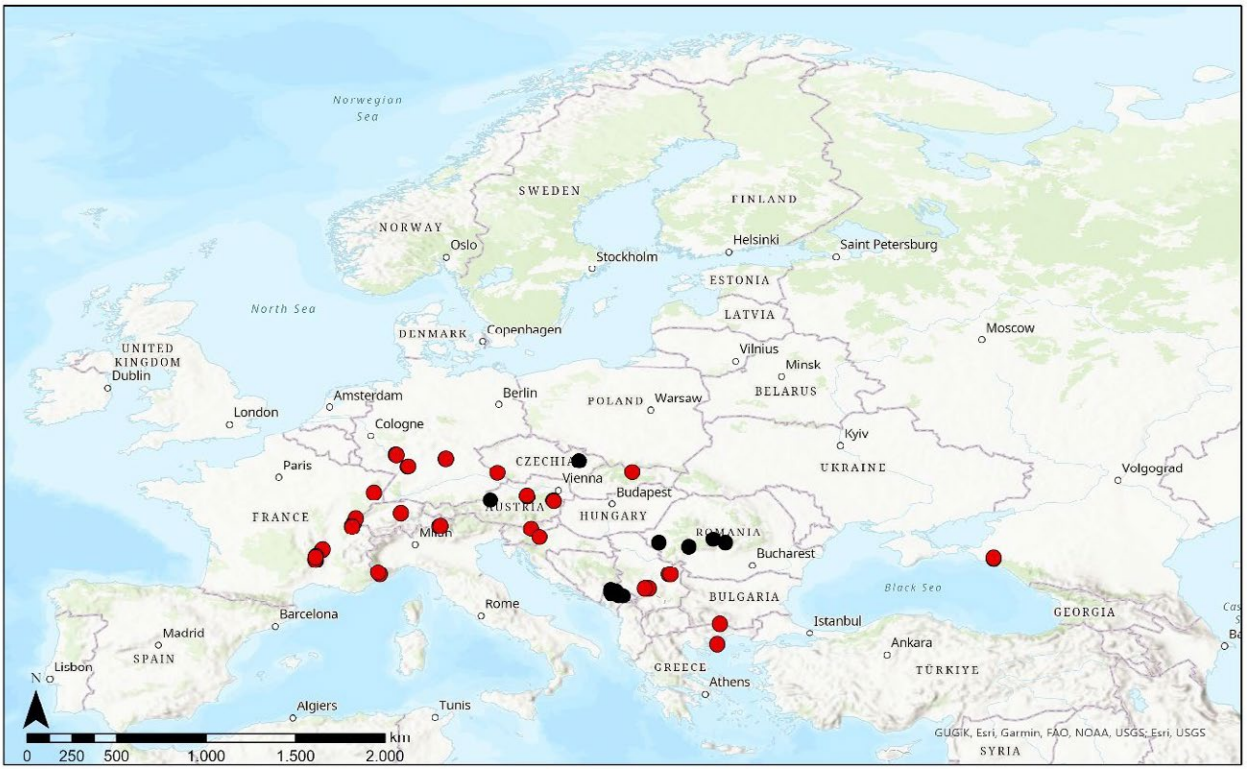

Figure 12: Records of Brachypalpus chrysites from Bradescu (1993), GBIF, iNaturalist, Observation.org. and Schmid and Moertelmaier (2009); black dots: old and undated records; red dots: recent records (2008–2022).

Current distribution and demography

Schmid and Moertelmaier (2007) describe *Brachypalpus chrysites* as a 'montane insect', occurring in the mountains of south-central Europe up to the Pyrenees (Speight, 2020). It occurs in the Tatra Mountains (Poland), the Czech Republic, Schwarzwald (Germany), through the Alps (France, Germany, Switzerland, Liechtenstein, Austria, Slovenia), Slovakia, Serbia, the Carpathian region (Ukraine), eastern Romania, Greece, Türkiye and the European parts of Russia Federation (Figure 12; Pennards *et al.,* 2021a; Speight, 2020). The estimated extent of occurrence (EOO) in Europe is approximately 1.7 million km² and the area of occupancy (AOO) is 706 km² (464 km² in the EU). Despite the wide distribution, the small AOO indicates a fragmented distribution (Pennards *et al.,* 2021a).

Habitat and resource assessment

The preferred habitat of *Brachypalpus chrysites* is open conifer forest with veteran trees (mainly *Picea*, *Abies*, *Larix*, *Pinus*) (Vujić *et al.,* 2020). In Central Europe, these forests are often restricted to forest reserves, which are usually intensively managed (Lindenmayer *et al.,* 2012). As a result of intensive logging and unsustainable management in general, the lack of dead wood in Central European forests is causing not only the decline in biodiversity (Lassauce *et al.,* 2011), but also a change in the functional composition of the communities (Seibold *et al.,* 2015). As an example, in Germany, 27% of saproxylic species are threatened (Seibold *et al.,* 2015).

Threat analysis

According to Pennards *et al*. (2021a), the main threats to *Brachypalpus chrysites* are deforestation, livestock farming and urbanisation. In addition, habitat fragmentation threatens isolated subpopulations, as these are less likely to be recolonised (Pennards *et al.,* 2021a). Schmid and Moertelmaier (2007) discovered three individuals of *Brachypalpus chrysites* in the Hacklwald (10 km SW of Salzburg, Austria) in 1999. The Hacklwald consists of large coniferous forests which have been intensively used for forestry. As a result, Schmid and Moertelmaier (2007) describe an increasing destruction of veteran trees in the forest leading to habitat destruction for the species.

Another threat, which is not easy to quantify, is climate change (Pennards *et al.,* 2021a). This species has been assessed as Vulnerable on the IUCN Red List of Threatened Species (Pennards *et al.,* 2021a) and is listed as Vulnerable on the Red Lists of Germany (Ssymank & Doczkal, 1998), Bavaria (von der Dunk *et al.,* 2003) and Baden-Württemberg (Doczkal *et al.,* 2001). Pennards *et al*. (2021a) stress that the focus of protection should be conserving the species habitat.

Table 4. Threat analysis for Brachypalpus chrysites based on Pennards et al. (2021a).

Threat	Priority	Timing	Knowledge	Presumed current impact
Wood and pulp plantations	1	Ongoing	Medium	High
Tourism and recreation areas	2	Ongoing	Medium	Medium
Human intrusion and disturbance –work and other activities	3	Ongoing	Low	Low
Climate change and severe weather – habitat shifts and alterations	4	Ongoing	Low	Medium

Jacobson's Leafwalker, *Chalcosyrphus jacobsoni* (Stackelberg, 1921)

Species description

Systematics / taxonomy

Chalcosyrphus jacobsoni (Stackelberg, 1921) (Figures 13–14) is a saproxylic hoverfly species. In northern Europe, several common names exist: Nordlig Mulmblomfluga in Swedish, Nordlig Råtevedblomsterflue in Bokmål, Norwegian, Idänpuuhari in Finnish and Nordleg Ròtevedblomsterfluge in Nynorsk, Norwegian. *Xylota jacobsoni* Stackelberg, 1921 is the basionym (original name under which it was described).

Figure 13: Chalcosyrphus jacobsoni. (Photo by Andrea Klintbjer/SLU Artdatabanken)

Figure 14: Chalcosyrphus jacobsoni. (Photo by Gunilla Ståhls)

This species is relatively small (8–11 mm), somewhat elongated and predominantly black with yellowish tibia bases, yellow tarsi and moderately thickened hind femora. The eyes of the male only touch at one point, unlike in similar species (*Chalcosyrphus nigripes* and *Xylota suecica*), where the eyes are touching over a longer distance. In general appearance, *C. jacobsoni* and *C. nigripes* are similar. The females of *C. eunotus* and *C. jacobsoni* are also similar in appearance (Speight, 2020).

Biology and ecology

The preferred habitats of this species are forests and wetlands; mosaics of boreal *Picea/Pinus/Betula* forests and mires with veteran trees and plentiful fallen timber in waterlogged conditions (H. Bartsch, pers. comm.) in the northern taiga belt (Speight, 2020). In Finland, a number of specimens were caught by Malaise trapping in 2013 and 2014. The traps were located in the Kuusamo area and some adjacentareas, in landscapes with bogs, mires and forest patches (G. Ståhls, pers. comm.). In Norway, there isa report of a female found in humid *Alnus* and *Pinus* forest (Nielsen & Svendsen, 2014). The flight period is June and July. It has been observed feeding on *Salix* spp. (Pestov, 2010) and *Caltha* sp. (Bagatshanova, 1990). It spends most of its life cycle in the larval stage, but there are no data on the developmental stages.

Functions and values

Chalcosyrphus jacobsoni is one of the rare saproxylic species mainly occurring in northern Europe. It is also typical in the sense of its preferred habitat, which includes both wetland and boreal forests, so it can be considered a good indicator species for changes happening in these particular habitat types.

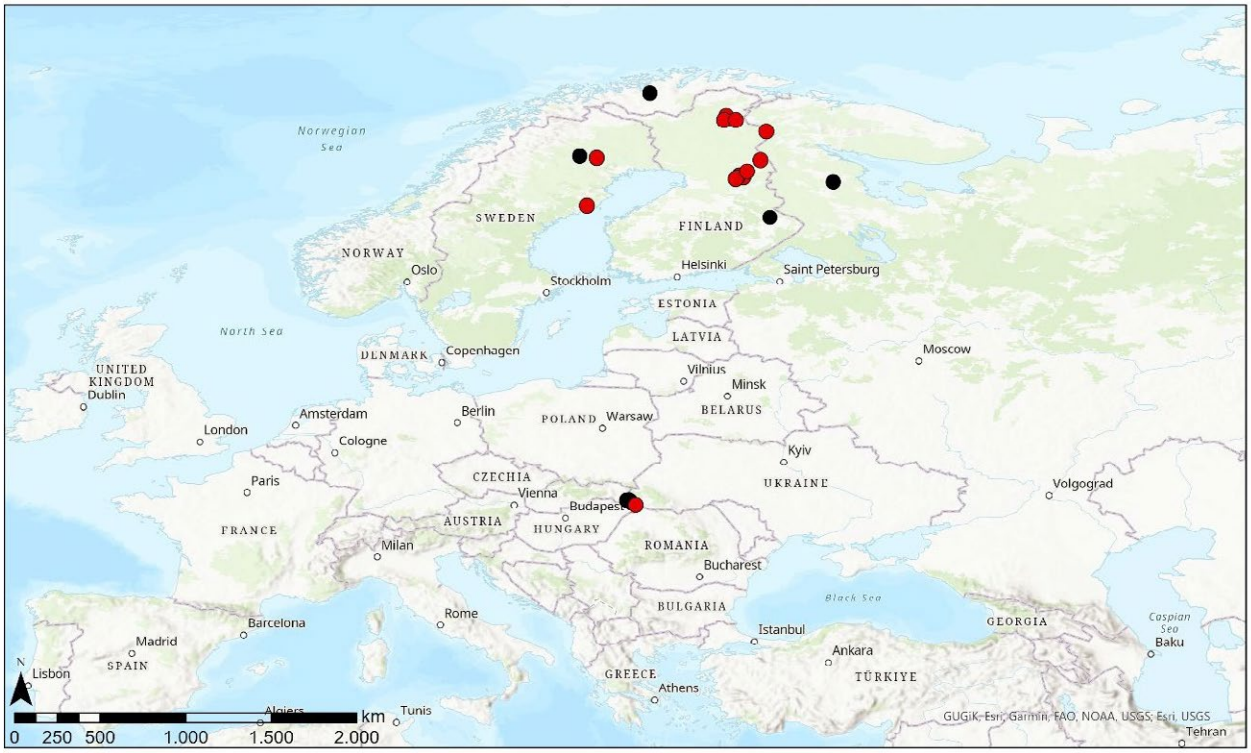

Figure 15: Records of Chalcosyrphus jacobsoni from Anikina, GBIF, Nielsen and Svendsen (2014), Speight and Stackelberg; black dots: old and undated records; red dots: recent records (2005–2020).

Historical distribution

The historical distribution of *C. jacobsoni* was presumably wider than known based upon the records, reaching further south than today (Figure 15). The range in the Carpathians is likely to be a relic of the former wide distribution. The record from Ukraine is from the 1960s and no recent records exist, so this species is possibly extinct there (G. Popov, pers. comm.). The main reason for the range reduction is most probably inadequate forest management practices.

Current distribution and demography

This species is rare in northern Europe and probably extinct in Ukraine (Figure 15). The extent of occurrence (EOO) of *Chalcosyrphus jacobsoni* is estimated to be around 2.5 million km^2 and the area of occupancy (AOO) around 72 km^2. In Europe, it is found in northern Norway, northern Sweden, northern Finland and the northern parts of European Russia Federation. Pennards *et al*. (2021c) state that recent records in Sweden and Norway are also very limited.

Habitat and resource assessment

Chalcosyrphus jacobsoni is mainly found in boreal forests. Although most of these forests have retained the resilience to cope with current disturbances, projected environmental changes of unprecedented speed and amplitude pose a substantial threat to their health (Gauthier *et al.*, 2015). Venäläinen *et al*. (2020) state that in northern Finland forests, an area coinciding

with the distribution of *C. jacobsoni*, the risk of snow damage is anticipated to increase in the future, while increasing drought in summer will increase the risk of large-scale forest fires. However, detailed information about specific habitats in localities where the species has been recorded is not available.

Threat analysis

Pennards *et al*. (2021c) state that similarly to most of the wood-dwelling species, forest management is the main threat for *Chalcosyrphus jacobsoni*, particularly conversion of natural forests to more intensively managed forests. Continuing decline of suitable habitat, and also the growing threats from climate change will play an important role in the future. Distributional changes are to be expected, with movements towards higher altitudes as a result of climate change. The occurrence of forest fires a few years ago in Sweden and Norway poses additional, but probably minor threat, and is another consequence of climate change.

Table 5. Threat analysis for Chalcosyrphus jacobsoni based on Pennards et al. (2021c).

Threat	Priority	Timing	Knowledge	Presumed impact
Logging and wood harvesting	1	Ongoing	Medium	High
Climate change and severe weather – habitat shifts and alterations	2	Ongoing	Medium	High
Wood and pulp plantations	3	Ongoing	Low	Medium
Fire and fire suppression	4	Ongoing	Low	Medium
Droughts	5	Ongoing	Low	Low

Black-legged Leafwalker, *Chalcosyrphus nigripes* (Zetterstedt, 1838)

Species description

Systematics / taxonomy

Chalcosyrphus nigripes (Zetterstedt, 1838) is a saproxylic species, originally described as *Xylota nigripes* (Zetterstedt, 1838) (Figure 16). It has the common names Svart Mulmblomfluga (in Swedish) and Mustapuuhari (in Finnish). It is a relatively small, completely black and moderately elongated species with thickened femora. The males of *Chalcosyrphus nigripes* have a body size of 8–11 mm. The scutellum, thorax sides and mesoscutum are glossy black with light yellow hair. The abdomen is all black with metallic shiny bands (which may be broken in the middle) on tergites 2–4. The legs are usually completely black; however, the femora tips and tibia bases may be yellowish. The female of *C. nigripes* is undescribed but may also be similar to *C. jacobsoni*, but probably with more thickened femora. *Chalcosyrphus nigripes* is very similar to *Chalcosyrphus jacobsoni* and *Xylota suecica*.

Figure 16: Chalcosyrphus nigripes. (Photo by Jere Kahanpää)

Biology and ecology

Data on the biology and ecology of *C. nigripes* are scarce. The preferred habitat is forest – mainly arctic-alpine *Betula* forest and western taiga. Bartsch *et al*. (2009) state that the larva develops in sap or under bark of deciduous trees, especially birch, but mentions spruce and pine as possible host plantsas well. There are no data on flowers visited by this species. The flight period is from the end of May to the beginning of July. The developmental stages are not described, but they were reared by Bagatshanova (1990) from larvae collected from under the bark of *Larix* stumps and logs. It appears to overwinter as a larva (Speight, 2020).

Functions and values

Chalcosyrphus nigripes is saproxylic, and such species have been used as indicators of woodland quality (Ricarte *et al.,* 2009; Speight, 1989). They have also been proposed as indicators of climate change (Rotheray & Gilbert, 2011).

Historical distribution

The oldest records of *Chalcosyrphus nigripes* are from Finland from the 1920s (Figure 17; FinBif, 2020). There are no recent findings in Finland (G. Ståhls, pers. comm., 2022).

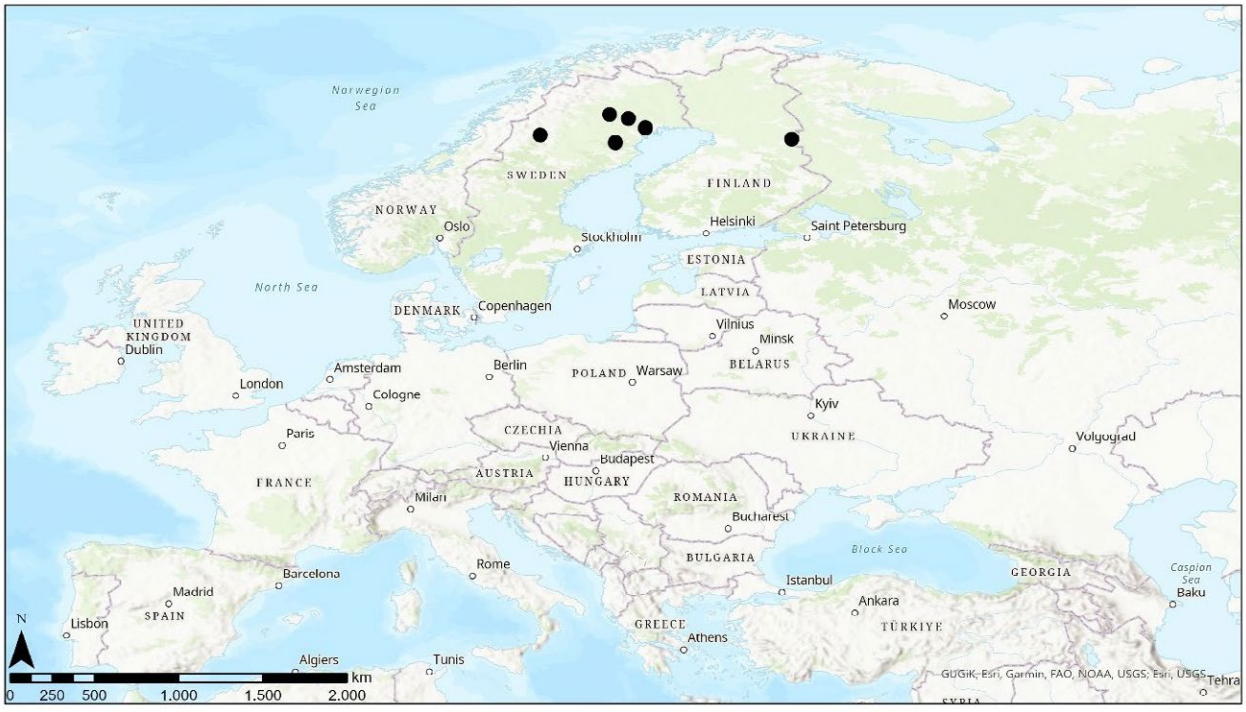

Figure 17: European Records of Chalcosyrphus nigripes from GBIF.

Current distribution and demography

This species is very rare and restricted. It is found in Sweden (Artdatabanken, 2019), northern Finland, Siberia and into eastern Russian Federation (Speight, 2020). The extent

of occurrence (EOO) of this species in Europe is estimated to be around 1.7 million km^2 and the area of occupancy (AOO) is estimated to be around 44 km^2. According to Pennards *et al*. (2021d), there are no available records from European Russian Federation although it is likely to also occur there. All records are old, the most recent from 1978, so the species is likely to be very rare in its whole range of northern Europe and European Russian Federation.

Habitat and resource assessment

Bartsch *et al*. (2009) describes *Chalcosyrphus nigripes* as mainly connected with deciduous trees, because it develops in sap or under their bark, especially birch, but mentions spruce and pine as possible as well. He also states that it is found in northern forests – usually old growth stands in the vicinity of wetlands.*Chalcosyrphus nigripes* is a very rare and local species, with only a few scattered records. This could be the reason why its habitat requirements (among other aspects of its biology and ecology) are poorly known.

Threat analysis

According to Pennards *et al*. (2021d), the main threat to this species is the loss of quality and quantity of habitat through activities such as logging and forest plantations. It may also be threatened by climate change due to changing rainfall patterns and extreme weather events (droughts). Distributional changes (influenced by climate change) are to be expected, and it will most likely shift its range towards higher altitudes (to colder and wetter areas). Threats mentioned are ongoing and affect the species at the ecosystem level, causing conversion and degradation of ecosystems, as well as at the species level, impacting mortality. However, the intensity of threats remains unknown, as well as their scope.

Table 6. Threat analysis for Chalcosyrphus nigripes, based on Pennards et al. (2021d).

Threat	Priority	Timing	Knowledge	Presumed current impact
Logging and wood harvesting	1	Ongoing	Medium	High
Deforestation	2	Ongoing	Medium	Medium
Commercial and industrial areas,mining	3	Ongoing	Low	Low
Climate change and severe weather – habitat shifts and alterations	4	Ongoing	Low	Medium
Changing rainfall patterns	5	Ongoing	Low	Medium

Hoverflies specialised on veteran trees: threat analysis

The threat analysis for hoverflies specialised on veteran trees was developed in the context of the European Red List of Hoverflies: 'Moving from Assessment to Conservation Planning'. The following is based upon this analysis and represents selected parts from the IUCN SSC HSG/CPSG (2022).

Microhabitats associated with veteran trees (TreMs) include trunk cavities, rot holes, fallen timber and tree stumps. Their decline can arise through the removal of entire veteran trees within standing forests, parks and gardens, the replacement or loss of species that produce good veteran tree microhabitats (e.g. oak, willow, poplar, beech and other species), and the negative impacts of changing climatic conditions.

Removal of veteran trees within standing forest

Entire veteran trees may be felled in parks, recreational forests and along roads, and in production forests to protect the safety of the public or forestry workers, to avoid disease to commercial tree crops (veteran trees are perceived to be a source of disease), to improve forestry efficiency by realising economic benefits more quickly and to produce firewood for the public or for foresters as extra income.

Replacement or loss of key tree species

Oaks are particularly important for saproxylic species because they are especially long-lived; they maintain the old wood parts in the crown and can live with rotting parts. Tree holes tend to grow withthe age of the tree, and they develop a large variety of microclimatic and moisture conditions with different degrees of decomposing material (Ssymank, 2016; Ssymank *et al.,* 2019). Oaks are being replaced for economic reasons. They have a long production time and faster-growing species are favoured. In addition, infestations of oak processionary (*Thaumetopoea processionea*) and gypsy moths *(Lymantria dispar*), whose caterpillars feed on oak leaves, can cause damage and lower timber production. Though otherwise healthy oak trees can survive infestation and regrow leaves later in the year, infested oaks may be cut and replaced by other tree species. Sometimes, to combat mass infestation, large-scale aerial spraying of biological pesticides is conducted, which targets the larvae of moths and butterflies but also has significant toxic effects on flies. However, this type of pesticide application is fortunately decreasing.

Decline or absence of hoverfly-friendly forest and woodland management

Old coppicing practices create good habitat for saproxylic hoverfly larvae because of the old trunks and the creation of fissures. However, coppiced forests of species such as *Carpinus* (hornbeam), *Castanea* (sweet chestnut) and various oaks, including Mediterranean species *Quercus frainetto, Q. cerris* and *Q. pubescens*, are being removed to make way for more lucrative forestry. A less entomologically useful form of coppiced forestry now occurs in the Mediterranean.

Succession planning for veteran trees is essential to the long-term viability of hoverflies with saproxylic larvae. Saproxylics can maintain populations for several years on a few or even just one old tree (e.g. van Steenis *et al.,* 2019). However, such populations are vulnerable, if unable to move elsewhere when the existing tree dies or is removed. Microhabitat continuity, both on the same tree and within the same area (noting that most of these species are good fliers, so this can mean "within kilometres"), is essential.

Removal of veteran tree features

Clearing trees uprooted by winds (windthrows) and removing all fallen or broken trees after major storms destroys important habitat for saproxylic hoverfly groups. Fallen timber can be removed for forest hygiene and tidiness or along forest streams for better water flow. Removal is particularly common along roads and watercourses. Fallen timber may also be collected for firewood either by the public or by foresters to supplement income. Removal of tree humus from cavities, to use as potting compost, can destroy a microhabitat that can take decades to regenerate.

Large-scale forestry

A lack of veteran trees and decaying wood is also a result of large-scale forestry, which usually creates monocultures of fast growing trees of similar age. This threat has been identified specifically for both *Chalcosyrphus nigripes* and *Chalcosyrphus jacobsoni*, but is a major driver of loss of saproxylic insects in general.

Changing climate, extreme weather

Premature death of trees *in situ* is occurring as a consequence of increasing frequencies of droughts. The impact of this process on veteran trees is accelerating in the Mediterranean following a succession of extreme weather events. Veteran trees are now dying prematurely. Climate change is influencing modern forestry towards promoting whatever species are most able to cope with the changes, even if non-native. Wet oak forest is threatened by water abstraction (both for drinking and irrigation) in combination with climate change. Root systems are adapted to the climatic situation of the soil, so when this changes it creates a cascade of issues.

Wildfires

Frequent forest fires over large areas in the Mediterranean pose a serious problem to both habitat and hoverfly conservation and may be increasing as a consequence of climate change. Dead wood for saproxylic hoverfly larvae needs to be moist, so there are fewer of these species associated with Mediterranean microhabitats, but some that do occur there are threatened. Damaging impacts from fire are more likely in homogeneous managed forests, and those not actively managed for fires.

Conservation planning

To develop a conservation strategy for the target pollinator species, the approach of the IUCN Species Survival Commission was adopted according to the *IUCN Guidelines for Species Conservation Planning* (IUCN SSC Species Conservation Planning Sub-Committee, 2017) and the *Species Conservation Planning Principles and Steps* (CPSG, 2020). A draft strategy was prepared by a core group of stakeholders and discussed and amended during a participatory workshop, involving species specialists and planners, state government agencies, managers, researchers, NGOs and other stakeholders.

Conservation Action Plan

Vision

Veteran trees and decaying wood adjacent to flower-rich habitats are well represented and connected in European landscapes, providing sustainable habitat for specialist hoverflies. Threatened hoverfly species dependent on veteran trees or decaying wood have self-sustaining, healthy populations, so that future generations can enjoy them and benefit from the services they provide.

Authorities, foresters, arboriculturists, conservationists and local communities are aware of the importance of veteran trees and decaying wood for maintaining biodiversity and engage in conservation action for veteran trees and hoverflies dependent on them. Sustainable forestry and arboricultural practices valuing and preserving veteran trees and decaying wood and encouraging future veteran trees are in place.

The vision was carefully worded to reflect the following points:

(i) "Veteran trees and decaying wood": the larval ecology of hoverflies is diverse and for manyspecies not yet understood. Some species prefer sap-runs, while others may prefer decaying wood or rot holes. It is essential to preserve the full diversity of potential habitat structures to ensure survival of hoverfly species.

(ii) "adjacent to flower-rich habitats": in order to protect the full habitat of hoverflies, it is necessary not only to protect their nesting sites, but also the foraging habitat of adult hoverflies.

(iii) "well represented and connected": habitats of hoverflies specialised to veteran trees have become increasingly rare and fragmented as a consequence of active removal of veteran trees. Habitat loss, degradation and fragmentation constitute major threats to these species. These habitats need to be maintained, extended and re-connected by appropriate management and habitat restoration.

(iv) "providing sustainable habitat for specialist hoverflies": habitat protection andmanagement is key to the survival of threatened species. This particularly includes sustainable management and protection of veteran trees and decaying wood.

(v) "self-sustaining, healthy populations": this highlights the aim to improve the status of threatened hoverfly species for the long term.

(vi) "future generations can enjoy them and benefit from the ecosystem services they provide": insects (particularly hoverflies) provide multiple ecosystem services including pollination, but are also of high aesthetic and educational value and indicators for biodiversity. This is particularly true for hoverflies specialised to veteran trees, but also for their habitat, which supports large numbers of other species.

(vii) "Authorities, foresters, arboriculturists, conservationists and local communities are aware of the importance of veteran trees and decaying wood for maintaining biodiversity": this highlights the responsibility of multiple actors and the need for increased awareness of the value of veteran trees and decaying wood and the main threats.

(viii) “Sustainable forestry and arboricultural practices”: transformative changes of land use are necessary in forestry, but also in the maintenance of veteran trees outside forests.

Goals, objectives and actions

Goal 1: Governance and protection

Governance and protection established and secured for hoverflies specialised to veteran trees, in their priority countries and at a European level, providing leadership and implementation of the conservation plan; as well as protection via recognition in plans for associated protected habitats and pollinators.

Objective 1.1: Governance

To establish a steering group by 2023 in order to guide and facilitate implementation of the plan and review progress regularly.

Actions

1.1.1 Creation of a steering group

Purpose: To ensure the implementation of all actions
Note: Regular meetings each year to review progress (more often during the first year)
Who: IUCN SSC Hoverfly Specialist Group (HSG) / IUCN SSC Invertebrate Conservation Committee (ICC) / Buglife (BL) / IUCN European Office (IUCN) / Syrphidae in Trees (SiT) / VETCERT
By when: 2023
Indicator: Regular meetings
Resources required: Volunteer time

1.1.2 Facilitate implementation of the action plan

How: Coordination at European level / European Commission to facilitate uptake of the plan by European authorities / exchange on management practices and experiences
Who: HSG / ICC / IUCN / EC
By when: 2023
Indicator: Coordinator employed
Resources required: 1 full time project coordinator (PC), 2 PhD students, budget for meetings with local actors, training and coordination of citizen scientists, consumables, travel costs

Objective 1.2: Improving national protection

To ensure that veteran trees and moist decaying wood receive better protection and the six hoverfly species, *Sphiximorpha petronillae*, *Chalcosyrphus pannonicus*, *Primocerioides regale*, *Brachypalpus chrysites*, *Chalcosyrphus jacobsoni* and *Chalcosyrphus nigripes* with their habitats are fully protected under national laws in their countries of occurrence.

Actions

1.2.1 Conduct national Red List (re-)/ assessments for hoverflies in the following European countries: Greece, Bulgaria, Romania, Croatia, Slovenia, Austria, Italy, France, Slovakia, Czech Republic, and support Red List assessments in other countries, such as Switzerland, Montenegro, Ukraine

Notes: Red List assessments are a valuable basis for protection (countries without any existing records at the moment may be added later if discovered); Hoverfly Red Lists exist in Finland (2019), Sweden (2020), Norway (2021) and Germany (2011)
Who: HSG / PC
Collaboration recommended: National conservation agencies / authorities
By when: 2028
Indicator: National Red Lists for hoverflies exist, including assessments of *Sphiximorpha petronillae*,*Chalcosyrphus pannonicus*, *Primocerioides regale*, *Brachypalpus chrysites*, *Chalcosyrphus jacobsoni* and *Chalcosyrphus nigripes*
Resources required: Coordinator, meetings, staff time

1.2.2 Add Sphiximorpha petronillae, Chalcosyrphus pannonicus, Primocerioides regale, Brachypalpuschrysites, Chalcosyrphus jacobsoni and Chalcosyrphus nigripes to national lists of protected species Details: Which species should be listed in which country: S. petronillae: Italy, Serbia, Montenegro, Greece; C. pannonicus: Bosnia-Herzegovina, Bulgaria, Croatia, Greece, Poland, Romania, Serbia,Slovakia, Ukraine; P. regale: Greece, Serbia; B. chrysites: Austria, Czech Republic, France, Germany, Italy, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Switzerland; C. jacobsoni: Finland, Norway, Russian Federation (north- east), Sweden, Ukraine; C. nigripes: Finland, Sweden

Note: Protection needs to be done via the habitat, research still needs to be possible
Who: HSG / IUCN
Collaboration recommendation: National NGOs / National environmental ministries & conservationauthorities / Academic institutions
By when: 2030
Indicator: Species on list of protected species
Resources required: Staff time, communication to policy makers

1.2.3 Explore existing policies and legal instruments for the protection of veteran trees

Note: Frameworks to protect veteran trees exist in some countries, but may not be suitable tomaintain hoverfly habitats; consider also the EU Common Agricultural Policy (CAP)
Who: PC
Collaboration recommendation: EC / National authorities / Forestry authorities
By when: 2026
Indicator: Report on existing instruments
Resources required: Staff time, communication to policy makers

1.2.4 Instigating legal frameworks or policies for the protection of veteran trees in countries withoutany existing protection

Who: HSG / IUCN / PC
Collaboration recommendation: National authorities / Forestry authorities
By when: 2028
Indicator: Legal frameworks established
Resources required: Staff time, communication to policy makers

Objective 1.3: Improving European protection

To improve the protection of veteran trees and the specialist hoverfly species, *Sphiximorpha petronillae*, *Chalcosyrphus pannonicus*, *Primocerioides regale*, *Brachypalpus chrysites*, *Chalcosyrphus jacobsoni* and *Chalcosyrphus nigripes* (under existing legislation) in Europe.

Actions

1.3.1 Consideration of veteran trees and wet decaying wood as well as the specialist hoverflies in theexpansion of the European protected area network

How: Key habitats with veteran trees and dead wood should be included in the protected areanetwork
Who: IUCN / HSG / PC
Collaboration recommendation: EC / National authorities
By when: 2025

Indicator: Inclusion of veteran trees and wet decaying wood in protected areas (PA) network
Resources required: Staff time

1.3.2 Ensure protection of veteran trees in the context of the European Commission's proposal for a Regulation on nature restoration[1]

How: Provide recommendations for including veteran trees and wet decaying wood as indicators of forest restoration in the implementation of the proposed Regulation

Note: Consider affiliation of hoverflies with Annex I habitats
Who: EC / IUCN / HSG
By when: 2025
Indicator: Implementation of the Regulation on nature restoration considers veteran trees
Resources required: Staff time

1.3.3 Convene a stakeholder platform with foresters and arboriculturists to provide recommendationson optimal management of veteran trees and moist decaying wood

How: Recommendation that the platform is convened in the context of the implementation of the EU Pollinators Initiative2
Note: Use existing platforms if possible, check Old-growth forest mapping, Close to Nature Forestry Guidelines
Who: HSG / IUCN / CEPF
Collaboration recommendation: EC
By when: 2026
Indicator: Stakeholder platform exists
Resources: Staff time, meetings

Objective 1.4: Integration in existing plans

To integrate conservation of veteran trees, moist decaying wood and specialist hoverflies in existing action plans at European, national and local scale.

Actions

1.41.1 Ensure consideration of veteran trees, moist decaying wood and their specialised hoverflies inthe EU habitat action plans

Notes: Veteran trees are mentioned twice in the documents 'Natura 2000 and forests' (Part I–III) withthe aim to create a network of strict forest reserves (SFR) covering 2% of forest area. Dead wood and dying trees are more often mentioned. Best practice guidance is currently only available for habitat types 4030 (dry heaths) and 6210 (semi-natural dry grasslands), but not for important forest types (9XXX).
How: Instigate EU habitat action plans for forests, facilitate implementation of the 2% target for strict forest reserves
Who: PC / HSG
Collaboration required: EC
By when: 2025
Indicator: Veteran trees and moist decaying wood considered in implementation of habitat action plans
Resources required: Staff time

1.4.2 Ensure consideration of veteran tree specialised hoverflies in national action plans for insects and biodiversity strategies

Note: Action plans for insects exist in several countries / Dead wood mentioned in German Biodiversity
Strategy (but vague) / Research required to check national action plans / biodiversity strategies for information on veteran trees or decaying moist wood / strong engagement of member states required

1 COM(2022) 304
2 COM/2023/35

How: Organise meetings with actors on how the action plans are being implemented and how to best consider veteran trees and decaying moist wood
Who: PC / HSG
By when: 2025 / 2029
Indicator: Veteran tree conservation included in national action plans
Resources required: Staff time

Objective 1.5: Coverage in protected areas

To ensure that a high number of populations of threatened veteran tree specialised hoverfly species, *Sphiximorpha petronillae*, *Chalcosyrphus pannonicus*, *Primocerioides regale*, *Brachypalpus chrysites*, *Chalcosyrphus jacobsoni* and *Chalcosyrphus nigripes* are covered by protected areas.

Actions

1.5.1 Conducting a gap analysis to obtain an overview of the number of hoverfly populations specialised to veteran trees (Sphiximorpha petronillae, Chalcosyrphus pannonicus, Primocerioides regale, Brachypalpus chrysites, Chalcosyrphus jacobsoni and Chalcosyrphus nigripes) in- and outside protected areas

How: GIS analysis / use survey data from 2.1.1
Who: PC / PhD student(s) (PhD) / HSG
By when: 2027
Indicator: Report
Resources required: Staff time

1.5.2 Instigate planning and designation of protected areas of currently unprotected key populationsof Sphiximorpha petronillae, Chalcosyrphus pannonicus, Primocerioides regale, Brachypalpus chrysites, Chalcosyrphus jacobsoni and Chalcosyrphus nigripes

How: Close collaboration with local authorities and NGOs required
Who: HSG
By when: 2030
Indicator: All key populations covered by protected areas
Resources required: Staff time

Goal 2: Research

Population status, dynamics and associated drivers, habitat requirements and likely future threats ofhoverflies specialised to veteran trees, as well as ecological roles and management benefits better understood.

Objective 2.1: Improving knowledge of population status

To improve knowledge of the current population status, distribution and genetic uniqueness ofveteran tree specialised hoverflies.

Actions

2.1.1 .Conduct field surveys at localities of all historic records of veteran tree specialised hoverflies in the European Union and neighbouring countries as well as potential habitats

How: Conduct targeted field work to reconfirm these localities; needs several survey years because of phenologies / use remote sensing data to find single veteran trees
Note: S. petronillae can be found using ant knowledge (but note that the ant is very widespread and present in many places where S. petronillae cannot be found)
Who: HSG / SiT / local hoverfly experts

Collaboration required: local PA authorities / STING project (EUPOMS) 3
By when: 2026 / 2029
Indicator: Comprehensive information on past and current distribution, publication
Resources required: Staff time, travel costs

2.1.2 Study genetic diversity of remaining populations of veteran tree specialised hoverfly species in Europe

How: Non-invasive or minimal invasive (tarsi, legs) collection during survey (2.1.1), DNA analysis; usingeDNA (from trees)
Note: Barcoding library is not complete in all countries; ideally use novel genomic methods, e.g. Single Nucleotide Polymorphisms (SNPs).
Who: University of Novi Sad (UNS) / University of Helsinki (UH) / SiT
Collaboration recommended: metabarcoding experts (Trier University (TU))
By when: 2029
Indicator: Genetic analysis available, publication
Resources required: Staff cost (PhD student), Lab costs

2.1.3 Study distribution of veteran trees in Europe and create a European database of veteran trees.Note: Some databases exist (Italy, Sweden, UK); Sweden has The Swedish Oak Project (https://www.gu.se/en/research/the-swedish-oak-project) as well as a database of veteran trees in thegeneral Swedish Observation System (https://www.artportalen.se/), a citizen science based European Database exists as well: https://www.monumentaltrees.com (citizen science); VETCERT maintains a professional database

Note: Prediction of localities from ancient tree database in UK available (could be used also on European level) Nolan *et al.* (2020, 2021, 2022)
Who: PC / PhD / SiT / VETCERT
Collaboration recommended: foresters, arboriculturists, botanists, PA managers, citizen scientists
By when: 2026
Indicator: Model of potential ancient tree distribution exists
Resources required: Staff time, travel costs

Objective 2.2: Improving knowledge of ecology and habitat requirements

To improve knowledge of the ecological specialisation and habitat preferences of veteran tree specialised hoverflies, including suitable tree species and conditions, population connectivity, and interactions with other species as well as habitat availability.

Actions

2.2.1 Research on larval habitat preferences (tree species, microhabitat, decay stage) for the sixprioritised veteran tree specialised hoverfly species

Who: HSG / UNS / SiT
Note: Use of eDNA could be helpful / study if protection of hole is necessary (wire mesh) / fungi may play a role (volatiles)
Collaboration required: PA managers
By when: 2028
Indicator: Publication
Resources required: Staff time (PhD student), travel costs, lab costs

2.2.2 Research on necessary spatial requirements (and number of veteran trees or amount of decayingdead wood required) of the prioritised veteran tree specialised hoverflies

Who: HSG / UNS / SiT
By when: 2028
Indicator: Publication
Resources required: Staff time (PhD student), travel costs

3 EU Pollinator Monitoring Scheme

2.2.3 Study on the connectivity of populations, mobility of selected hoverfly species with focus ondispersal

How: Mark-recapture: / population genetics / eDNA / check newest technological developments / focus on species where enough individuals can be found
Learn from work on Hammerschmidtia ferruginea in Scotland (Rotheray *et al*.) Who: HSG / UNS / SIT
Collaboration required: PA managers
By when: 2028
Indicator: Publication
Resources required: Staff time (PhD student), travel costs

2.2.4 Field survey to quantify availability of suitable and potential trees and appropriate microhabitats for the target hoverfly species

How: Structured, replicated surveys of plots of adequate extent to determine tree age structure, presence of decay, rot holes or other characteristics of importance, such as the ant, Liometopum microcephalum, altitude, etc. where appropriate.
Who: HSG / UNS
Collaboration required: PA managers
By when: 2028
Indicator: Publication
Resources required: Staff time (PhD student, PA staff), travel costs

Objective 2.3: Improving knowledge to mitigate threats and improve management

To obtain the information necessary to mitigate threats to veteran tree specialised hoverflies and improve conservation management of existing and restored habitats.

Actions

2.3.1 Study methods to create breeding sites for veteran tree specialised hoverflies to promote their populations

How: Veteranisation techniques / breeding boxes (see https://www.syrphidaeintrees.com/)
Who: HSG / PC / SIT / VETCERT
Collaboration required: PA managers / other scientists
By when: 2027
Indicator: Publication
Resources required: Staff time (PhD student), travel costs

2.3.2 Development of best practice guidance for habitat management and restoration of veterantrees, decaying moist wood and specialist hoverflies

How: Develop a document with recommendations regarding management of veteran trees
Note: Buglife has done a lot of work on this as part of the Ancients of the Future project – see https://www.buglife.org.uk/resources/ancient-tree-hub/ and associated pages.
Who: HSG / ICC / IUCN / PC / SIT / VETCERT
Collaboration required: PA managers / foresters / arboriculturists
By when: 2025 (update 2030)
Indicator: Guidelines available
Resources required: Staff time

2.3.3 Study on how other habitats with trees (parks, gardens) can promote the species

Note: Parks often have old trees, records exist from parks, what about pollarded trees:
How: Collect data on old trees and survey them for hoverflies
Who: HSG / UNS / PC / SIT / VETCERT
By when: 2028
Indicator: Report available
Resources required: Staff time (PhD student), travel costs

2.3.4 Study on effects of climate change on the availability of habitat

How: Species distribution modelling for all veteran tree specialised hoverflies / consider also habitat modelling / using data from survey / using also the veteran tree database (2.1.3)
Who: UNS / HSG / SiT
By when: 2028
Indicator: Publication
Resources required: Staff time / PhD student

2.3.5 Study the effect of wildfires on veteran tree specialised hoverfly populations

Notes: Not clear whether wildfires may even benefit some hoverfly species; Dadia burnt recently, but only pine forests and open scrublands were affected;
Who: PC / HSG / UNS
Collaboration: University of the Aegean / WWF Greece / PA managers
By when: 2029
Indicator: Publication
Resources required: Staff time / PhD student

Objective 2.4: Monitoring

To develop and implement population monitoring for veteran tree specialised hoverflies as well asmonitoring of the effects of conservation measures.

Actions

2.4.1 Development of a standardised monitoring protocol for veteran tree specialised hoverflies

How: Use non-lethal monitoring (surveys in spring, how many larvae or adults) / train PA staff / focus on the rarest species and key sites of other species / explore whether eDNA or bioacoustics can be used
Who: HSG / PC / SiT
Collaboration recommended: PA staff, citizen scientists, STING project (EUPOMS)
By when: 2026
Indicator: Standardised monitoring protocol established
Resources required: Staff time, travel costs, management of volunteers

2.4.2 Integration of monitoring scheme for veteran tree specialised hoverflies in European PollinatorMonitoring Scheme (EUPOMS)

Details: Monitoring of threatened species is planned in the EUPOMS 'Rare Species Module' Who: ICC / HSG / SiT
Collaboration required: STING project, EC
By when: 2026
Indicator: Veteran tree specialised hoverflies considered in EUPOMS
Resources required: Staff time

2.4.3 Establishment of a monitoring scheme for effectiveness of conservation actions for threatenedveteran tree specialised hoverflies

How: Permanent monitoring of key populations needed (some species develop over several years), analyse population trends in response to conservation actions / use spatially explicit information
Who: HSG / PC / SiT
Collaboration required: PA managers
By when: 2027
Indicator: Monitoring scheme established
Resources required: Staff time

Goal 3: Conservation action

A European-wide increase in the number and connectivity of veteran trees and decaying wood tosustain populations of veteran tree specialised hoverflies.

Objective 3.1: Veteran tree management

To implement optimised management for threatened veteran tree specialised hoverflies in

protected areas and other areas under conservation management.

Actions

3.1.1 Ensure that existing management plans of relevant Natura 2000 sites and other protected areasconsider veteran tree specialised hoverflies

How: Review existing plans, contact authorities, amend plans if necessary
Who: PC / HSG / VETCERT
Collaboration recommended: EC / Local authorities
By when: 2027
Indicator: Report
Resources required: Staff time

3.1.2 Adapt local forest management to protect and increase the number of veteran trees and amount of decaying moist wood in areas with occurrence of any of the target species.

How: Implementation of best practice guidance (2.3.2)
Where: Start in areas with currently existing populations of Sphiximorpha petronillae, Chalcosyrphus pannonicus and Primocerioides regale
Who: PC / HSG / ICC / IUCN / VETCERT
Collaboration required: PA managers
By when: 2025
Indicator: Management adapted
Resources required: Staff time, workshops, machines

3.1.3 Explore options to reintroduce Sphiximorpha petronillae, Chalcosyrphus pannonicus and

Primocerioides regale in areas or countries where they are regionally extinct

Note: Habitat preservation and restoration has the highest priority, this is just a potential additional option after sufficient research has been done on habitat requirements, threats and feasibility; some experience in Scotland (Ellen Rotheray)
How: Requires sound knowledge of current population status, habitat requirements, etc.; needs thorough reintroduction planning
Who: PC / HSG / ICC
Collaboration required: IUCN SSC Conservation Translocation Specialist Group
By when: 2030
Indicator: Assessment of reintroduction options
Resources required: Staff time

Objective 3.2: Improving population connectivity

To improve population connectivity by identifying potential future veteran trees for microhabitat promotion in critical sites for dispersal and expansion of threatened veteran tree specialised hoverflypopulations.

Actions

3.2.1 Identify priority areas for future veteran tree habitats

How: Use results of Species Distribution Models (2.3.4) – overlap with availability of veteran trees (gap analysis)
Who: UNS / HSG / PC / Kiel University (CAU)
By when: 2029
Indicator: Spatial model
Resources required: Staff time

3.2.2 Habitat preservation: Develop guidance for those providing training to foresters linked to Forest Certification Processes

Purpose: Mark trees to protect them from logging
How: Identified high quality veteran trees should be marked so that they will not be logged
Who: HSG / PC

Collaboration required: Local conservation authorities / foresters / park staff / VETCERT
By when: 2026 / 2029
Indicator: Tree preservation in place
Resources required: Staff time, meetings

3.2.3 Creating larval habitat in areas with occurrence of highly threatened species How: Small cutting into living trees to produce sap-run / breeding boxes (see 2.3.1)

Who: PC / HSG / SIT / BL
Collaboration required: Park staff / foresters
By when: 2025 / 2028
Indicator: Artificial habitats created
Resources required: Staff time

Goal 4: Threat reduction

A reduction in key threats and improvement of habitat availability for veteran tree specialised hoverflies across key sites in priority countries.

Objective 4.1: Reduce threats and enhance habitat availability in the wider landscape

To improve forest management and arbori-culture in the wider landscape by applying veteran treefriendly techniques.

Actions

4.1.1 Provide training material on how to recognise high value veteran trees

Who: HSG / PC
By when: 2025
Indicator: Material developed
Resources Required: Staff time, material

4.1.2 Promote veteran tree survival in forests in the general wider landscape

Who: HSG

Collaboration required: EC / National / Regional forestry authorities / Arboriculturists
By when: 2025 / 2030
Indicator: Mechanism to support protection of veteran trees
Resources required: Staff time, meetings

4.1.3 Promote veteran tree survival in public spaces (roadsides, parks, gardens, etc.)

How: Meetings with authorities for public spaces
Who: IUCN / HSG / ICC
Collaboration required: Authorities in charge of green spaces / Environmental authorities / EC / NGOs
/ EU Green City Accord / Eurocities / ICLEI
By when: 2025
Indicator: Mechanism to support protection of veteran trees
Resources required: Staff time, meetings

4.1.4 Promote veteran tree survival in agricultural areas

How: Via CAP (e.g. agri-environmental schemes, landscape features)
Who: IUCN / HSG / EC / IEEP
Collaboration required: CAP network
By when: 2025
Indicator: Mechanism to support protection of veteran trees
Resources required: Staff time, meetings

4.1.5 Promote integrated pest management and reinforce recommendation to ban or reduce pesticides and herbicides in forests and parks

How: Integration into the implementation of the European Commission's proposal for a Regulation on the Sustainable Use of Plant Protection Products4
Who: IUCN / ICC

Collaboration recommended: EC / National forestry and environmental authorities / authorities for public spaces
By when: 2028
Indicator: Integrated pest management plans exist for areas with veteran trees
Resources required: Staff time, meetings

Goal 5: Public awareness

Use specialist hoverflies as flagship species to increase awareness of the value of veteran trees and decaying moist wood for biodiversity and their threats, as well as local communities actively engagedin their conservation.

Objective 5.1: Public awareness of veteran tree specialised hoverflies

To increase public awareness of veteran trees, decaying moist wood and their specialised hoverflies in Europe.

Actions

5.1.1 Prepare general outreach material (infographics, etc.) on veteran trees, decaying moist wood andtheir specialised hoverflies, including information on their species assemblages, biodiversity values and need for conservation and fact sheets for each species

Note: needs to be translated into languages of priority countries
Who: HSG / ICC / PC / SIT
By when: 2024 (update based upon completed actions 2028)
Indicator: Outreach material available
Resources required: Staff time, designer

5.1.2 Create information signs in areas with occurrence of threatened veteran tree specialisedhoverflies to inform about the values, habitats and threats.

How: Use outreach material from 5.1.1. (+QR code to more detailed information, e.g. on Pollinator Information Hive page)
Who: PC / HSG / SIT
Collaboration required: PA managers / Local conservation authorities / Foresters
By when: 2026 (update 2029)
Indicator: Signs exist in areas with veteran tree specialised hoverfly occurrence
Resources required: Staff time, material, designer

5.1.3 Provide information about the veteran tree specialised hoverflies action plan andimplementation on the EU Pollinator Information Hive

Details: Publish action plan on Pollinator Information Hive, provide outreach material from 5.1.1 and case studies from 5.1.4
Who: HSG / PC / IUCN / SIT
Collaboration required: EC
By when: 2023 (yearly updates afterwards)
Indicator: Information exists on Pollinator Information Hive
Resources required: Staff time

5.1.4 Provide case studies on successful veteran tree conservation approaches

How: Distribute via IUCN SSC Species e-bulletin / WCPA newsletter / PARKS journal / DG ENV (Natura 2000 newsletter) / EU Pollinator Information Hive / Journaal van Syrphidae / distribute to foresters and authorities / gardening journals / landscape planners

4 COM/2022/305

Who: HSG / ICC / IUCN / PC / SIT
Collaboration required: Europarc
By when: 2029
Indicator: Case studies published
Resources required: Staff time

5.1.5 Awareness raising with foresters

How: Meet with local forestry (in areas with occurrence of the hoverfly species) to discuss options to adapt management / Use information material for foresters to promote veteran trees and decaying moist wood / oases of biodiversity
Who: PC / HSG / SIT
Collaboration required: Local authorities / Park managers / foresters / CEPF / EUSTAFOR
By when: 2026
Indicator: Meetings with foresters conducted
Resources required: Staff time, meetings, material

Objective 5.2: Citizen engagement

To provide means for citizens, communities and institutions, including youth, to engage in the conservation of veteran trees, decaying moist wood and their specialised hoverflies by maintaining veteran trees or contributing to surveys.

Actions

5.2.1 Facilitate the development of a label 'Veteran Tree Biodiver-City' to distinguish municipalities which maintain veteran trees in parks

How: Develop a catalogue of requirements to obtain the label
Notes: Ancient Tree Forum; https://www.checktrees.com/; https://www.vetcert.eu/
Who: HSG / IUCN / PC / SIT
Collaboration required: municipalities / VETCERT
By when: 2026
Indicator: Label exists
Resources required: Staff time, material

5.2.2 Engage citizens in veteran tree specialised hoverfly surveys

How: Take pictures of hoverflies on veteran trees and submit via online platforms (like for example https://www.spipoll.org/ in France; iNaturalist, observation.org)
Who: HSG / UNS / SIT
Collaboration required: PA managers / local NGOs / Naturalist platforms
By when: 2027
Indicator: Citizen science monitoring started
Resources required: Staff time, training

5.2.3 Engage citizens in creating larval habitats for veteran tree specialised hoverflies

How: Breeding boxes ('Hoverfly lagoons') / veteranisation techniques (in their gardens or forests)
Note: Use experience by Ellen Rotheray
Who: HSG / SIT
Collaboration required: NGOs
By when: 2025
Indicator: Campaign started
Resources required: Staff time, outreach material (planning material)

Annex (timelines of the plan)

Annex (timelines of the plan)

The plan is organised in two phases (2023–2026 and 2027–2030). Grey cells show general times of activity, while dark grey cells show the milestones as defined in the action plan.

Action	Short Title		2023	2024	2025	2026	2027	2028	2029	2030
1.1.1	Creation of a steering group		x	x	x	x	x	x	x	x
1.1.2	Facilitate implementation of the action plan		x							
1.2.1	National Red Lists			x	x	x	x	x	x	x
1.2.2	National List of protected species			x	x	x	x	x	x	x
1.2.3	Explore existing policies and legal instruments			x	x	x				
1.2.4	Instigate policies in countries without such						x	x	x	
1.3.1	Veteran trees in European PA network			x	x	x				
1.3.2	European Nature Restoration Regulation			x	x					
1.3.3	Stakeholder platform			x	x	x				
1.4.1	Veteran trees in EU habitat action plans			x	x	x				
1.4.2	National action plans / biodiversity strategies			x	x	x	x	x	x	x
1.5.1	Gap analysis						x			
1.5.2	PA planning for unprotected key populations			x	x	x	x	x	x	x
2.1.1	Survey of historic records			x	x	x	x	x	x	
2.1.2	Genetic diversity of hoverfly populations						x	x	x	
2.1.3	Veteran tree database			x	x	x				
2.2.1	Research on larval habitat preferences			x	x	x	x	x		
2.2.2	Research on spatial requirements					x	x	x		
2.2.3	Study on population connectivity and mobility				x	x	x	x		
2.2.4	Study on microhabitat availability				x	x	x	x		
2.3.1	Study on artificial breeding sites			x	x	x	x			
2.3.2	Best practice guidelines				x					x
2.3.3	Study on alternative habitats (parks, gardens)				x	x	x	x		
2.3.4	Study on effects of climate change						x	x		
2.3.5	Study on effects of wildfires						x	x	x	
2.4.1	Standardised monitoring protocol					x	x	x	x	x
2.4.2	Integration in EUPOMS					x				
2.4.3	Monitoring effectiveness of conservation action						x	x	x	x

Hoverflies specialised to veteran trees in Europe
Conservation action plan 2023–2030

Annex(timelines of the plan)

3.1.1	Integration in plans of protected areas				x	x	x			
3.1.2	Adaptation of local forest management			x	x	x	x	x	x	x
3.1.3	Assess reintroduction options								x	x
3.2.1	Identify priority areas for future veteran trees						x	x	x	x
3.2.2	Guidance for forest certification processes				x	x	x	x	x	
3.2.3	Larval habitat creation				x	x	x	x	x	x
4.1.1	Training material to recognise veteran trees			x	x	x	x	x	x	x
4.1.2	Promote veteran trees in wider landscape			x	x	x	x	x	x	x
4.1.3	Promote veteran trees in agricultural areas			x	x	x	x	x	x	x
4.1.4	Promote pesticide reduction			x	x	x	x	x	x	x
5.1.1	Prepare general outreach material			x	x	x	x	x	x	x
5.1.2	Information signs			x	x	x	x	x	x	
5.1.3	Info on EU Pollinator Information Hive		x	x	x	x	x	x	x	x
5.1.4	Case studies on successful management							x	x	x
5.2.1	Label ‘Veteran Tree Biodiverse-City’			x	x	x	x	x	x	x
5.2.2	Citizens in hoverfly surveys						x	x	x	x
5.2.3	Citizens in habitat creation				x	x	x	x	x	x

References

Aracil, A., Pérez, C., Rojo, S., Barkalov, A., Mazánek, L., Pennards, G. W. A., Popov, G., Speight, M., & Vujić, A. (2021a). *Primocerioides regale*. The IUCN Red List of Threatened Species 2021. e.T149170563A152281823. Downloaded on 22 August 2022.

Aracil, A., Pérez, C., Rojo, S., Barkalov, A., & Speight, M. (2021b). *Sphiximorpha petronillae*. The IUCN RedList of Threatened Species 2021: e.T149170214A152281759. Downloaded on 09 July 2022.

Artsobservasjoner. 2019. Available at: https://www.artsobservasjoner.no/.

Bagachanova, A. K. (1990). Fauna i ekologiya mukh-zhurchalok (Diptera, Syrphidae) Yakutii. *YakutskNauchnye Tsentr*, 1164.

Bartsch, H., Binkiewicz, E., Klintbjer, A., Rådén, A., & Nasibov, E. (2009). Tvåvingar: Blomflugor. Diptera:Syrphidae: Syrphinae. ArtDatabanken, SLU, Uppsala.

Burgio, G., Sommaggio, D., & Birtele, D. (2015). I Sirfidi (Ditteri): biodiversità e conservazione. ISPRA,*Manuali e Linee Guida*, 128, 1–182.

Conservation Planning Specialist Group (CPSG) (2020). Species Conservation Planning Principles & Steps. Appley Valley, MN: IUCN SSC Conservation Planning Specialist Group.

Doczkal D., Rennwald K., & Schmid U. (2001). Rote Liste der Schwebfliegen (Diptera: Syrphidae) Baden-Württembergs. Naturschutz-Praxis/Artenschutz; Landesanstalt für UmweltschutzBaden-Württemberg.

Drensky, P. (1934). Die Fliegen der Familie Syrphidae (Diptera) in Bulgarien. *Mitteilungen der Münchner Entomologischen Gesellschaft*, 8, 237–256.

FinBIF (2018). Finnish Biodiversity Information Facility/FinBIF. Finnish Museum of Natural HistoryLuomus, Helsinki. Available at: https://laji.fi/en. (Accessed: 6 March 2018).

Gauthier, S., Bernier, P., Kuuluvainen, T., Shvidenko, A. Z., & Schepaschenko, D. G. (2015). Boreal foresthealth and global change. *Science*, 349, 819–822.

IUCN Species Survival Commission (SSC) Species Conservation Planning Sub-Committee (2017). Guidelines for Species Conservation Planning. Version 1.0. Gland, Switzerland, 114 pp.

IUCN Species Survival Commission Hoverfly Specialist Group/ Conservation Planning Specialist Group (IUCN SSC HPG/CPSG) (2022) *European Hoverflies: Moving from Assessment to ConservationPlanning.* Apple Valley, MN, USA: Conservation Planning Specialist Group.

Larrieu, L., Paillet, Y., Winter, S., Bütler, R., Kraus, D., Krumm, F., Lachat, T., Michel, A. K., Regnery, B., & Vandekerkhove, K. (2017). Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. *Ecological Indicators*,84, 194–207.

Lassauce, A., Paillet, Y., Jactel, H., & Bouget, C. (2011). Deadwood as a surrogate for forest biodiversity:meta-analysis of correlations between deadwood volume and species richness of saproxylicorganisms. *Ecological Indicators*, 11, 1027–1039.

Lindenmayer, D. B., Laurance, W. F., & Franklin, J. F. (2012). Global decline in large old trees. *Science*, 338, 1305–1306.

Mielczarek L. E. (2014). The first records of *Chalcosyrphus pannonicus* (Oldenberg, 1916) (Diptera:Syrphidae) in Poland and Slovakia. *Bulletin of the Dipterological Section of the Polish Entomological Society,* 30, 50–54.

Nielsen, T. R. & Svendsen, S. (2014). Hoverflies (Diptera, Syrphidae) in North Norway. *NorwegianJournal of Entomology*, 61, 119–134.

Nolan, V., Gilbert, F., Reed, T., & Reader T. (2022). Discovering ancient and veteran trees in England. *Bulletin of the Ecological Society of America*, 103, e02013

Nolan, V., Reader, T., Gilbert, F., & Atkinson, N. (2020). The Ancient Tree Inventory: a summary of the results of a 15 year citizen science project recording ancient, veteran and notable trees across the UK. *Biodiversity and Conservation*, 29, 3103–3129.

Nolan, V., Reader, T., Gilbert, F., & Atkinson, N. (2021). Historical maps confirm the accuracy of zero- inflated model predictions of ancient tree abundance in English wood-pastures. *Journal of Applied Ecology*, 58, 2661–2672.

Pape, T., Blagoderov, V., & Mostovski, M. B. (2011). Order Diptera Linnaeus, 1758. In Z.-Q. Zhang, (eds.)Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa*, 3148, 222–229.

Pennards, G. W. A., Popov, G., & Speight, M. (2021a). *Brachypalpus chrysites*. The IUCN Red List ofThreatened Species 2021: e.T149167842A149167852, downloaded on 31 August 2022.

Pennards, G. W. A., van Eck, A., Popov, G., & Speight, M. (2021b). *Chalcosyrphus pannonicus*. The IUCN Red List of Threatened Species 2021: e.T149169888A149169893. downloaded on 07 August2022.

Pennards, G. W. A., Popov, G., & Vujić, A. (2021c). *Chalcosyrphus jacobsoni*. The IUCN Red List ofThreatened Species 2021: e. T149171001A149171004.

Pennards, G. W. A., Popov, G., & Vujić, A. (2021d). Chalcosyrphus nigripes. The IUCN Red List of

Threatened Species 2021: e.T149169930A149169935. Accessed on 30 September 2022.

Pestov, S. V. (2010). Seasonal dynamics of hoverfly (Diptera, Syrphidae) activity in the Taiga zone ofthe Komi Republic. *Entomological Review*, 90, 718–723.

Ricarte, A., Jover, T., Marcos-García, M. A., Micó, E., & Brustel, H. (2009). Saproxylic beetles (Coleoptera)and hoverflies (Diptera: Syrphidae) from a Mediterranean forest: towards a better understanding of their biology for species conservation. *Journal of Natural History,* 43, 583– 607.

Ricarte, A., Nedeljković, Z., Rotheray, G. E., Lyszkowski, R. M., Hancock, E. G., Watt, K., Hewitt, R. M., Horsfield, D., & Wilkinson, G. (2012). Syrphidae (Diptera) from Greek island of Lesvos, with description of two new species. *Zootaxa*, 3175, 1–23.

Rotheray, G. E. (1993). A colour guide to hoverfly larvae in Britain and Europe. *Dipterists Digest,* 9, 1–155.

Rotheray, G.E., & Gilbert F. (2011). *The Natural History of Hoverflies*. Ceredigion: Forrest text.

Rotheray, G. E., & MacGowan, I. (2000). Status and breeding sites of three presumed endangered Scottish saproxylic syrphids (Diptera, Syrphidae). *Journal of Insect Conservation,* 4, 215–223.

Rotheray, G. E., & Stuke, J.-H. (1998). Third stage larvae of four species of saproxylic Syrphidae (Diptera), with a key to the larvae of British Criorhina species. *Entomologist's Gazette,* 49, 209–217.

Schmid, U., & Moertelmaier, T. (2007). The larvae of *Brachypalpus chrysites* Egger, 1859 and

Chalcosyrphus valgus (Gmelin, 1790) (Diptera, Syrphidae). *Volcucella*, 8, 109–120.

communities (Diptera, Syrphidae) in response to land use across temperate Europe. *Oikos*, 116, 461–472.

Seibold, S., Brandl, R., Buse, J., Hothorn, T., Schmidl, J., Thorn, S., & Müller, J. (2015). Association ofextinction risk of saproxylic beetles with ecological degradation of forests in Europe. *Conservation Biology*, 29, 382–390.

SLU. ArtDatabanken. Available at: http://artfakta.artdatabanken.se.

Sohar, K., Helama, S., Läänelaid, A., Raisio, J., & Tuomenvirta, H. (2014). Oak decline in a southern Finnishforest as affected by a drought sequence. *Geochronometria*, 41, 92–103.

Soszyńska-Maj, A., Soszyński, B., & Klasa, A. (2009). Distribution and ecology of the saproxylic hoverfly *Chalcosyrphus eunotus* (Loew, 1873) (Diptera: Syrphidae) in Poland. *Fragmenta Faunistica*, 52, 191–195.

Speight, M. C. D. (1989). *Saproxylic invertebrates and their conservation*. Strasbourg (France): Councilof Europe.

Speight, M. C. D. (2020). Species accounts of European Syrphidae, 2020. Syrph the Net, the databaseof European Syrphidae (Diptera). *Syrph the Net Publications*, Dublin 104, 1–314.

Ssymank, A. (2012). Contributions to the fauna of hoverflies (Diptera: Syrphidae) of north-easternGreece, with special focus on the Rhodope Mountains with the Natura 2000 site Periochi Elatia, Pyramis Koutra. *Studia dipterologica,* 19, 17–57.

Ssymank, A. (2016). Biodiversität und Naturschutzaspekte in Eichen-Lebensraumtypen. *AFZ-DerWald,* 71, 10–13.

Ssymank, A., & Doczkal, D. (1998). Rote Liste Schwebfliegen (Diptera, Syrphidae). In Binot, M., R. Bless, P. Boye, H. Gruttke, and P. Pretscher. (eds.): Rote Liste gefährdeter Tiere Deutschlands. *Schriftenreihe für Landschaftspflege undNaturschutz,* 55, 65–72.

Ssymank, A., Buschmann, A., Röhling, M., Ellwanger, G., Brandt, K., & Jay, M. (eds.) (2019). Natura 2000Forest habitat types on secondary sites – conservation and management strategies. *Naturschutz und Biologische Vielfalt*, 167, 1–124.

van Steenis, J. (2023). Saproxylic breeding sites for hoverflies (Diptera: Syrphidae), from artificial design to natural habitat management. *Journaal van Syrphidae*, 2(1), 1–22. https:doi.org/ 1055710/DIOF2888.

van Steenis, J. (2016). The hoverfly (Diptera: Syrphidae) fauna of the nature reserve Hågadalen-Nåsten, Uppsala, Sweden. *Entomologisk Tidskrift*, 137, 111–129.

van Steenis, J., Nedeljković, Z., Tot, T., van der Ent, L.-J., van Eck, A., Mazánek, L., Šebić, A., Radenković,S., & Vujić A. (2019). New records of hoverflies (Diptera: Syrphidae) and the rediscovery of *Primocerioides regale* Violovitsh for the fauna of Serbia. *Biologia Serbica*, 41, 94–103.

van Steenis, J., Ricarte, A., Vujić, A., Birtele, D., & Speight, M. C. D. (2016). Revision of the West-Palearcticspecies of the tribe Ceriodini (Diptera, Syrphidae). *Zootaxa*, 4196, 151–209.

van Steenis, J., van Zuijen, M. P., Bot, S., van der Ent, L.-J., Barkalov, A., van Eck, A., Fleury, J., Földesi, R., Heimburg, H., Hadrava, J., Koch, B., Lutovinovas, E., Mazanek, L., Van de Meutter, F., Mielczarek, Ł., Palmer, C. J., Popov, G. V., Radenković, S., Reemer, M., … Wakkie, B. (2020). Faunistical overview of the European species of the genera Brachyopa Meigen, 1822 and Hammerschmidtia Schummel, 1834 (Diptera, Syrphidae). *Bonn Zoological Bulletin,* 69(2), 309–366. https://doi.org/10.20363/BZB-2020.69.2.309

Venäläinen, A., Lehtonen, I., Laapas, M., Ruosteenoja, K., Tikkanen, O. P., Viiri, H., Ikonen, V.-P., & Peltola, H. (2020). Climate change induces multiple risks to boreal forests and forestry in Finland: Aliterature review. *Global Change Biology*, 26, 4178–4196.

von der Dunk, K., Doczkal, D., Röder, G., Ssymank, A., & Merkel-Wallner, G. (2003). Rote Liste gefährdeter Schwebfliegen (Diptera: Syrphidae) Bayerns. *Schriftenreihe des BayerischenLandesamts für Umweltschutz*, 166, 291–298.

Vujić, M., Đurić, M., & Tot, I. (2021). Six new hoverfly species (Diptera: Syrphidae) in the fauna ofSerbia. Kragujevac. *Journal of Science,* 43, 149–155.

Vujić, A., Speight, M.C.D., de Courcy Williams, M., Rojo, S., Ståhls, G., Radenković, S., Likov, L., Miličić, M.,Pérez-Bañón, C., Falk, S., & Petanidou, T. (2020). Atlas of the Hoverflies of Greece (Diptera: Syrphidae) (pp. 1–384). Leiden, Netherlands: Koninklijke Brill NV.

Woodland Trust (2008). Ancient tree guide 4: What are ancient, veteran and other trees of specialinterest?