MOVING FROM ASSESSMENT TO CONSERVATION PLANNING FOR HOVERFLIES IN DENMARK

Miljøministeriet
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CONSERVATION PLANNING SPECIALIST GROUP
Changing the Future for Wildlife

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Cover photo credit: Karsten Thomsen. *Paragus finitimus* (Klithede-maskesvirreflue), assessed as Endangered (EN) in the Danish Red List.

Disclaimer: This document reports on a pilot project, designed and facilitated by the IUCN SSC Conservation Planning Specialist Group, at the request of the Danish Environmental Protection Agency (Miljøstyrelsen – MST). The analyses and recommendations generated should be considered the best advice from the stakeholder group involved, rather than the official viewpoint or plan of action from MST.

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International Union for Conservation of Nature (IUCN): is the global authority on the status of the natural world and the measures needed to safeguard it. It is a membership union uniquely composed of both government and civil society organisations. It provides public, private, non-governmental and indigenous peoples organisations with the knowledge and tools that enable human progress, economic development, and nature conservation to take place together.

IUCN Species Survival Commission (SSC): is the largest of IUCN's six volunteer Commissions with a global membership of 1000s of experts. SSC advises IUCN and its members on the wide range of technical and scientific aspects of species conservation and is dedicated to securing a future for biodiversity. SSC has significant input into the international agreements dealing with biodiversity conservation.

IUCN SSC Conservation Planning Specialist Group (CPSG): The Conservation Planning Specialist Group (CPSG) is a Specialist Group of the SSC of the IUCN. CPSG (Get to Know CPSG | Conservation Planning Specialist Group) designs and facilitates evidence based, stakeholder inclusive single and multi-species conservation planning processes and tools. Through CPSG's approach, planning participants create more effective conservation actions for species that also consider the social, cultural, and economic needs. When stakeholders participate actively and as equals in building the plan, they are much more likely to support its implementation. CPSG provides species conservation planning expertise and capacity building to other SSC Specialist Groups, government agencies, conservation practitioners, NGOs, ex situ institutions and other wildlife organisations. Apart from its headquarters in Minneapolis (USA), CPSG has 11 Regional Resource Centres (RRC) worldwide. CPSG Europe was established in 2002 and is hosted by Copenhagen Zoo, Denmark. The RRCs take CPSG tools and principles into local institutions of a region or country, allowing stakeholders to adapt CPSGs proven conservation techniques to meet their own unique needs.

IUCN SSC Hoverfly Specialist Group (HSG): was established in 2018. It brings together the experts around the world dealing with hoverflies, which through their work strive to assess the threat of extinction for these species through Red Listing, generate and disseminate scientific knowledge, engage in conservation actions of these species, and build public awareness about hoverfly significance.

The Danish Environmental Protection Agency (Miljøstyrelsen): The Danish Environmental Protection Agency is a part of the Ministry of Environment of Denmark. The agency provides dialogue with industry, knowledge of the environment and communication to citizens, and administers legislation and authorisations. The Environmental Protection Agency is organised into five centres: Centre for Rich Nature, Centre for Clean Water, Centre for Safe Chemistry, Centre for Green Production and Centre for Staff.

Syrph the Net (StN): is a hoverfly information database first published in 1997 (Speight and Castella, 2020). Its primary objective is to provide an analytical tool for standardising the degree of association between European hoverfly species and their habitats, microhabitats, and other attributes, thereby providing predictive capability. The latest version fully codes 800 of the known European species with the remaining approximately 150 species partially coded. The database is free, distributed electronically and its files are now accessible from all parts of the continent by naturalists, students,

conservation practitioners and researchers. It is maintained by Martin Speight and an editorial team comprising Emmanuel Castella, Jean-Pierre Sarthou and Cédric Vanappelghem.

CONTENT

Acronyms and Abbreviations

CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CPSG	IUCN SSC Conservation Planning Specialist Group
CPSG Europe	European Regional Resource Center of
EU POMS	European Union Pollinator Monitoring Scheme
FSC	Forest Stewardship Council
GBIF	Global Biodiversity Information Facility
HSG	IUCN SSC Hoverfly Specialist Group
IUCN	International Union for Conservation of Nature
MSP	Multispecies Plan
MST	The Danish Environmental Protection Agency (Miljøstyrelsen)
Natura 2000	Network of protected areas covering Europe's most vulnerable threatened species and habitats
Paragraph 3 (§3)	Protected habitats under the Danish Nature Protection Act (Naturbeskyttelsesloven)
SSC	IUCN Species Survival Commission
StN	Syrph the Net (see p. 3)

EXECUTIVE SUMMARY

MOVING FROM ASSESSMENT TO CONSERVATION PLANNING FOR HOVERFLIES IN DENMARK

The CBD's Post-2020 Global Biodiversity Framework, the EU Biodiversity Strategy for 2030 and the Nature 2030 IUCN Programme all include important and ambitious goals and targets for the conservation and recovery of the species and genetic diversity components of biodiversity. Confronted with hundreds, and sometimes thousands, of threatened species, many national and regional governments as well as other organisations with responsibilities for conserving wildlife, find it challenging to develop efficient, yet effective, methods of moving such large numbers of threatened species from Red List assessment to effective conservation action, at the pace demanded, and in a way that benefits from the knowledge, insights and support of key stakeholders. In particular it can be difficult to distinguish clearly between those threatened species that can be conserved through high-level strategies designed to address overarching threats to and drivers of biodiversity loss, and those whose recovery will likely also depend on species-specific attention in the form of 'intensive care' at the level of species, populations or gene diversity. The 'Assess to Plan' (A2P) process and associated multispecies planning (MSP) methodology developed by the Conservation Planning Specialist Group (CPSG) of the Species Survival Commission (SSC) of IUCN provides a workflow that addresses these challenges.

This pilot project, designed and facilitated by CPSG at the request of the Danish Environmental Protection Agency (Miljøstyrelsen – MST), applies this process to the threatened hoverflies of Denmark and can serve as a model for future work with other species groups in the country. As a pilot project, the analyses and recommendations generated should be considered the best advice from the stakeholder group involved, rather than the official viewpoint or plan of action from MST. Even though there is no funding stream associated with this plan, the full report and recommendations therein can guide and help promote positive action for hoverflies across a wide range of societal sectors, including but not limited to landowners, forest managers, large and small-scale farmers, policymakers, municipalities, NGOs, garden owners, amateur naturalists, zoos and botanic gardens, students, educators etc.

One of the fundamental planning principles of CPSG is that planning should be stakeholder inclusive. Through a process of neutral facilitation, stakeholders co-create a plan of action, making group decisions by consensus. Contributors to this project included Danish and international hoverfly specialists (including the Danish National Red List assessors), members of the IUCN SSC Hoverfly Specialist Group, representatives of Miljøstyrelsen, Naturstyrelsen, SEGES Innovation, Dansk Skovforening and Municipalities (Vejle and Odsherred).

Hoverflies were chosen as the subject of this pilot project because: CPSG had previously designed and facilitated a process to develop a multispecies, A2P-based plan of action associated with the European Red List for Hoverflies; there was interest within MST to work on Danish pollinators; there is a Danish Red List of hoverflies; and while hoverflies are the most important pollinator group after native bees, they are often missing in pollinator conservation efforts, despite their unique and diverse life histories and microhabitat requirements that need additional and different conservation measures.

The Danish Red List of hoverflies has assessments for 289 species. Of these 55 (or 19%) are assessed as threatened: 5 Critically Endangered, 24 Endangered, 26 Vulnerable. As a first step in the A2P/MSP process, information on the status and natural history for the 55 threatened species from the National Red List and other relevant databases was analysed in such a way that commonalities among species could be identified. In a second step, the threats and challenges to Danish hoverflies were discussed and analysed. Following these analyses, nine goals for hoverfly conservation in Denmark were formulated.

The identified goals for hoverfly conservation in Denmark

GOAL 1 Old and veteran trees, and their features, are valued and protected.

GOAL 2 Forest management supports hoverflies.

GOAL 3 There is a diverse herb layer in open areas as well as forests — and ecotones between them.

GOAL 4 Dune systems are dynamic and biodiverse.

GOAL 5 Natural hydrology is protected or restored — especially small water bodies and water-saturated ground.

GOAL 6 Pesticide use is rare and carefully targeted.

GOAL 7 Any commercial beekeeping practices in Denmark are compatible with hoverfly conservation efforts.

GOAL 8 There are sufficient tools, data, databases and experts for effective hoverfly monitoring and conservation in Denmark.

GOAL 9 Relevant sectors of society know what hoverflies are and are aware of their ecological value, conservation needs, and what they can do to help conserve them.

Considering a 10-year timeframe, collaborators went on to recommend objectives and actions aimed at mitigating threats and overcoming obstacles, in order to reach these goals. In developing these recommendations, they considered existing initiatives, policies and incentive schemes, (e.g. with regards to protection for single-standing trees, EU taxonomy initiative, FSC certification, forestry management, grazing and mowing, renewable energy, pesticide management and honey bee keeping etc.). They focused on recommending activities that are missing for hoverflies, or adjustments that could be made to existing strategies and policies to make them more hoverfly friendly – and by extension more biodiversity-friendly in general. These recommendations for hoverflies would also benefit many other (invertebrate) species groups, helping them to progress from threat assessment to recovery.

In a final step, the collaborators evaluated whether any of the threatened species require a single-species plan. This was deemed not to be necessary at this moment.

This approach has allowed the identification of new actions as well as recommended adjustments to existing initiatives, strategies, policies and incentive schemes that benefit both threatened and non-

threatened hoverflies as a group. Applying a similar approach to additional taxonomic groups with similar natural histories, macro- and microhabitats, threats and needs would now be easier, since there is likely considerable overlap in recommendations. Importantly, as this planning approach draws heavily on information captured during Red List assessments, future A2P/MSP projects would benefit from integration into the assessment process from the outset. This would help ensure that, where feasible, key information for conservation planning is identified and captured systematically, alongside other data, towards greater efficiency and utility for users.

RESUME

FRA VURDERING TIL FORVALTNING AF SVIRREFLUER I DANMARK

Den globale biodiversitetsmålsætning efter 2020 under Biodiversitetskonventionen (CBD), EU's biodiversitetsstrategi for 2030 og IUCN's Nature 2030-program inkluderer vigtige og ambitiøse mål og målsætninger for naturbevarelse og genopretningen af arter og genetisk diversitet.

Den nuværende biodiversitetskrise har medført hundreder og nogle gange tusinder af truede arter indenfor forskellige artsgrupper, som nationale regeringer og regionale myndigheder, såvel som andre organisationer med ansvar for naturforvaltning, skal finde løsninger for. Det er for mange en stor udfordring at udvikle effektive metoder, der kan flytte et så stort antal truede arter fra rødlistevurdering til effektiv forvaltning i det tempo, der er behov for, og på en måde, der anvender viden, ekspertise og støtte fra nøgleinteressenter. Det kan især være vanskeligt at skelne de truede arter, der kan forvaltes gennem strategier designet til at imødegå overordnede biodiversitetstrusler, fra dem, hvis genopretning sandsynligvis også vil afhænge af artsspecifik opmærksomhed i form af 'intensiv pleje' på arts-, populations- eller gendiversitetsniveau. 'Assess to Plan' (A2P-) processen og den tilhørende multispecies planning (MSP-) metode udviklet af Conservation Planning Specialist Group (CPSG) fra Species Survival Commission i IUCN er værktøjer til at løse disse udfordringer.

Dette pilotprojekt, designet og faciliteret af CPSG efter anmodning fra Miljøstyrelsen (MST), anvender CPSG-processerne på de truede svirrefluer i Danmark og kan være en model for fremtidigt arbejde med andre artsgrupper på nationalt niveau. Da dette er et pilotprojekt, bør analyserne og anbefalingerne betragtes som de bedste råd fra de involverede interessenter, frem for et officielt synspunkt eller en handlingsplan fra MST. Rapporten og anbefalingerne heri kan vejlede og hjælpe med at fremme positiv handling for svirrefluer på tværs af en bred vifte af sektorer i Danmark, herunder, men ikke begrænset til, jordejere, skovforvaltere, landmænd, politiske beslutningstagere, kommuner, ngo'er, haveejere, amatørnaturforskere, zoologiske og botaniske haver, studerende, undervisere m.fl.

Et af de grundlæggende planlægningsprincipper i CPSG er, at planlægningen skal være inkluderende for alle interessenter. Gennem en proces, der bygger på neutral facilitering skaber interessenterne samlet en handlingsplan ved konsensus. Bidragsydere til dette projekt er danske og internationale svirrefluespecialister (inklusive danske rødlistebedømmere af svirrefluer), medlemmer af IUCN SSC svirrefluespecialistgruppe, repræsentanter fra Miljøstyrelsen, Naturstyrelsen, SEGES Innovation, Dansk Skovforening og kommuner (Vejle og Odsherred).

Svirrefluer blev valgt til dette pilotprojekt fordi; man kunne drage nytte af, at CPSG tidligere har designet og faciliteret en proces til at udvikle en multispecies, A2P-baseret forvaltningsplan for den europæiske rødliste for svirrefluer; der var interesse fra MST for at arbejde med danske bestøvere; der er en dansk rødlistevurdering for svirrefluer; svirrefluer er den vigtigste bestøvergruppe lige efter hjemmehørende bier, men de mangler ofte forvaltning på trods af deres unikke og forskelligartede livshistorie og mikrohabitatkrav, der kræver yderligere og anderledes naturbevaringsindsatser.

På den danske rødliste er 289 arter af svirrefluer blevet vurderet. Af disse er 55 (19%) vurderet som truede (5 kritisk truede (CR), 24 truede (EN) og 26 sårbare (VU)). Som et første trin i A2P/MSP-processen blev oplysninger om status og naturhistorie for de 55 truede arter fra den nationale rødliste og andre relevante databaser analyseret, således at fællestræk mellem arter kunne identificeres. I andet trin blev truslerne og udfordringerne for danske svirrefluer diskuteret og analyseret. Efter disse analyser blev der formuleret ni mål for forvaltning af svirrefluer i Danmark.

De formulerede mål for forvaltning af svirrefluer i Danmark

MÅL 1 Gamle træer og veterantræer og deres egenskaber værdsættes og beskyttes.

MÅL 2 Skovforvaltning understøtter svirrefluer.

MÅL 3 Der er et varieret urtelag i åbne områder, såvel som i skove og økotoner imellem dem.

MÅL 4 Klitsystemer er dynamiske og biodiverse.

MÅL 5 Naturlig hydrologi beskyttes eller genoprettes — især små vandområder og vandmættede områder.

MÅL 6 Brugen af pesticider forekommer sjældent og eventuel brug er begrænset.

MÅL 7 Kommerciel biavlspraksis i Danmark er forenelig med indsatsen for at bevare svirrefluer.

MÅL 8 Der er tilstrækkelige værktøjer, data, databaser og eksperter til effektiv overvågning og bevaring af svirrefluer i Danmark.

MÅL 9 Relevante sektorer i samfundet ved, hvad svirrefluer er, og er bevidste om deres økologiske værdi, bevaringsbehov, og hvad de kan gøre for at hjælpe med at bevare dem.

Interessenterne havde også til opgave at fremsætte anbefalede mål og handlinger for en 10-årig periode, som vurderes at kunne afhjælpe truslerne og overvinde forhindringerne inden for tidsrammen. Ved udarbejdelsen af disse anbefalinger tog gruppen hensyn til eksisterende initiativer, politikker, og tilskuds- og støtteordninger (f.eks. beskyttelse af enkeltstående træer, EU-taksonomi, FSC-certificering, skovbrugsforvaltning, græsning og slåning, vedvarende energi, pesticidhåndtering, og honningbihold), og fokuserede på at anbefale aktiviteter, der mangler for svirrefluer, eller justeringer, der kunne foretages i eksisterende strategier og politikker for at gøre dem mere svirrefluevenlige – og i forlængelse heraf, mere biodiversitetsvenlige generelt. Disse anbefalinger for svirrefluer vil også gavne mange andre (hvirvelløse) artsgrupper og hjælpe dem med at vende tilbagegangen.

I et sidste trin, evaluerede interessenterne, om nogen af de truede arter kræver en særskilt forvaltningsplan. Dette blev vurderet til ikke at være nødvendigt på nuværende tidspunkt.

Denne nye tilgang til artsplanlægning har gjort det muligt at identificere nye tiltag, samt at anbefale justeringer af eksisterende initiativer, strategier, politikker og tilskuds- og støtteordninger, der gavner både truede og ikke-truede svirrefluer som gruppe. Ved at anvende samme tilgang til andre taksonomiske grupper med lignende naturhistorie, makro- og mikrohabitater, trusler og behov, vil planlægningsarbejdet være lettere, da der sandsynligvis vil være overlap i anbefalingerne. Da denne

planlægningstilgang i høj grad trækker på informationer, der er indsamlet under rødlistevurderinger, er det vigtigt at fremtidige A2P/MSP-projekter integreres i rødliste-vurderingsprocessen fra begyndelsen. Dette vil bidrage til at sikre, at nøgleoplysninger til forvaltningen, hvor det er muligt, identificeres og registreres systematisk sammen med anden data, og man dermed opnår større effektivitet og anvendelighed for brugerne.

THE PILOT PROJECT

AIM

The aim of this pilot project is to demonstrate how the Assess to Plan (A2P) process and associated multispecies planning (MSP) methodology developed by the Conservation Planning Specialist Group (CPSG) of the Species Survival Commission (SSC) of IUCN can be used to move more threatened species more rapidly from Red List assessment to effective conservation action through stakeholder-inclusive planning.

The Convention on Biological Diversity post-2020 Global Biodiversity Framework, the EU Biodiversity Strategy for 2030 and the Nature 2030 IUCN Programme all include important and ambitious goals and targets for the conservation and recovery of the species and genetic diversity components of biodiversity. Confronted with hundreds, and sometimes thousands, of threatened species, many national and regional governments as well as other organisations with responsibilities for conserving wildlife, find it challenging to develop efficient, yet effective, methods of moving such large numbers of threatened species from Red List assessment to effective conservation action, at the pace demanded, and in a way that benefits from the knowledge, insights and support of key stakeholders. In particular it can be difficult to distinguish clearly between those threatened species that can be conserved through high-level strategies designed to address overarching threats to, and drivers of, biodiversity loss, and those whose recovery will likely also depend on species-specific attention in the form of 'intensive care' at the level of species, populations or genetic diversity.

The 'Assess to Plan' (A2P) process and associated multispecies planning (MSP) methodology designed by CPSG provide a workflow that addresses these challenges. It was developed with the aim of moving more species, more rapidly, from assessment to conservation action, through stakeholder-inclusive planning. In general terms, A2P uses analyses of IUCN Red List data and/or additional relevant species databases, in combination with the input of local specialists, to identify a) groups of species whose overlapping needs can be planned for and acted on together through high-level priority strategies (either new ones, or existing strategies and work areas into which species or groups of species can be integrated); b) species whose needs do not overlap well with those of others and may need their own plans or some form of intensive care; c) next steps towards action for these species groups/strategies, and the individuals or agencies best placed to take it. A2P also helps ensure that stakeholders, collaborators, and resources are targeted efficiently, and that otherwise poorly known or lower-profile species receive the attention they need.

This pilot project, designed and facilitated by CPSG at the request of the Danish Environmental Protection Agency (Miljøstyrelsen – MST), adjusts and applies this process to a Danish context and to the threatened hoverflies of Denmark in particular, and can serve as a model for future work with other species groups in the country. The project has allowed the identification of new actions as well as recommended adjustments to existing initiatives, strategies, policies and incentive schemes that benefit both threatened and non-threatened hoverflies as a group. As a pilot project, the analyses and recommendations generated should be considered the best advice from the stakeholder group involved, rather than the official viewpoint or plan of action from MST. Though there is no funding stream associated with this plan, nevertheless, the full report and recommendations therein can guide and help promote positive action for hoverflies across a wide range of societal sectors, including but

not limited to landowners, forest managers, large and small-scale farmers, policymakers, municipalities, NGOs, garden owners, amateur naturalists, zoos and botanic gardens, students and educators etc.

Applying a similar approach to additional taxonomic groups with similar natural histories, (micro)habitats, threats and needs would now be easier, since there is likely considerable overlap in recommendations. Importantly, as the A2P/MSP planning approach draws heavily on information captured during Red List assessments, future projects in Denmark would benefit from integration into the assessment process from the outset. This would help ensure that where feasible, key information for conservation planning is identified and captured systematically, alongside other data, towards greater efficiency and utility for users.

WHY HOVERFLIES?

Hoverflies were chosen as the target taxonomic group for this Danish pilot project because:

- CPSG had recently designed and facilitated a process to develop a multispecies, A2P-based plan of action associated with the European Red List for Hoverflies (IUCN SSC HSG/CPSG 2022). In 2018, The European Union launched a comprehensive EU Pollinator initiative, that extends action to not only bees and butterflies, but all main pollinator groups (a new revised version of the EU Pollinator Action Plan is now available). Given their unusually diverse life histories and microhabitat requirements, hoverflies need additional and different measures from those of other groups, to ensure that they are adequately conserved and to realise the full range of benefits provided by them. Recognising this, the IUCN European Red List of Hoverflies initiative extended its work to draft a preliminary multispecies plan of action for European hoverfly species identified as threatened with extinction. Both the information gathered, tabulated and analysed for this project and framework of action proposed at European level, form a rich source of information that can be used to support national action planning;
- There was interest within MST to work on Danish pollinators;
- There is a National Red List assessment of hoverflies;
- Despite their environmental and economic significance – for instance being the most important pollinator group after native bees, hoverflies are often missing in pollinator conservation efforts. Where included under the broad banner of 'pollinators', their specific needs are often not adequately addressed because of their highly specialised and diverse life histories and microhabitat requirements that need additional and different conservation measures;
- Key hoverfly experts, including the IUCN SSC Hoverfly Specialist Group, were interested in collaborating with the Danish project, which may form a model for other countries aiming to stimulate and streamline action on the ground for hoverflies and other pollinators.

WORKSHOP SCOPE

This project covers all hoverfly species that are listed in the threatened categories of the Danish Red List 2019. The Red List has assessments for 289 species. Of these, 55 (or 19%) are assessed as threatened: 5 Critically Endangered (CR), 24 Endangered (EN) and 26 Vulnerable (VU).

PLANNING APPROACH

One of the fundamental planning principles of CPSG is that planning should be stakeholder inclusive. Through a process of neutral facilitation, stakeholders co-create a plan of action, making group decisions by consensus. Contributors to this project included Danish and international hoverfly specialists, members of the IUCN SSC Hoverfly Specialist Group, representatives of Miljøstyrelsen, Naturstyrelsen, SEGES Innovation, Dansk Skovforening and Municipalities (Vejle and Odsherred). For a complete list of contributors, see Appendix 2.

As a first step in the A2P/MSP process, information on the status and natural history of the 55 threatened species as available in the Danish Red List and in the 'Syrph the Net' (StN) database of European Syrphidae (Diptera) was analysed in such a way that commonalities among species could be identified. The database is a comprehensive, up-to-date and centralised repository of information covering all species of hoverfly recorded from Europe and Turkey. The database is a set of spreadsheets into which are coded data on various species attributes, including macrohabitat, microhabitat, traits, range, and status. For more information, see: https://pollinators.ie/record-pollinators/hoverflies/syrph-the-net/. Hoverflies have a rich diversity in larval microhabitats and feeding traits. In order to provide good homes for hoverflies, macrohabitats need to offer the required microhabitat features. Analysis of the microhabitats important for the threatened species was therefore an important component of the process.

Paragus finitimus (Klithede-maskesvirreflue), assessed as Endangered (EN) in the Danish Red List.
Photo © Karsten Thomsen

In a second step, the contributors to the project participated in a facilitated online workshop to review and identify threats to Danish hoverflies and to analyse which dynamics lie at the cause of the threats,

and how these threats impact the hoverflies. Given the importance of a large diversity of microhabitats for hoverflies, the loss of these for larvae, adults or their food constituted an important category of threats, but also other threats were identified and analysed. In addition, challenges to hoverfly conservation were identified.

Following these analyses, in a third step, project contributors gathered for a facilitated in person workshop. They formulated goals for hoverfly conservation in Denmark and, considering a 10-year timeframe, recommended lines of work, objectives and actions aimed at mitigating threats and overcoming obstacles, in order to reach these goals. In developing these recommendations, they considered existing initiatives, policies and incentive schemes and focused on recommending activities that are missing for hoverflies, or adjustments that could be made to existing strategies and policies to make them more hoverfly friendly – and by extension more biodiversity-friendly in general.

In a fifth and final step, the collaborators evaluated whether a) any of the threatened species requires a single-species plan because its circumstances are so different from those of the others that it will not sufficiently benefit from actions recommended in this multispecies plan; or b) any of the threatened species requires a form of 'intensive care' such as management of populations or gene diversity *in situ* (e.g. translocations and artificial provision of microhabitats) or *ex situ* (e.g. breeding/rearing away from the natural location for insurance or reintroduction/reinforcement purposes and *ex situ* research). Neither of these two options was deemed to be necessary at this moment. With the current knowledge, the group felt it was reasonable to assume that recommended actions would also benefit the Danish hoverflies currently listed as Near Threatened, Least Concern or Data Deficient, and that some of the regionally extinct species may return as (micro)habitats are restored to more suitable conditions.

HOVERFLIES IN DENMARK

"In Denmark we have many beautiful species of hoverflies – twice as many as birds. Like birds and orchids, they can be highly specialised and rare. If you pay careful attention, great experiences may be provided by the hoverfly".[1]

SPECIES STATUS

Denmark is home to 303 species of hoverflies. The Red List has assessments for 289 species. Of these 55 (or 19%) are assessed as threatened: 5 Critically Endangered (CR), 24 Endangered (EN) and 26 Vulnerable (VU). In addition, 32 species were categorised as Near Threatened (NT), 10 are Regionally Extinct (RE) and 18 were listed as Data Deficient (DD). All other species (174) were assessed as Least Concern (LC).

Adult hoverflies feed mainly on pollen and nectar (Thompson & Rotheray, 1998). They range in their appearance from large bumblebee mimics to tiny, hairless species, and with mimicry of bees and wasps being the most widespread (IUCN SSC HSG/CPSG 2022; Howarth et al., 2004; Penney et al., 2012). Their ecology is largely determined by the needs of the larvae, which vary substantially in biology and feeding requirements (see box 1). The two stages of hoverfly life cycles are very distinct. Both are important with regards to conservation. The larvae of many hoverfly species are highly specialised and hence strong indicators of particular ecological niches. The adults of many hoverfly species are visually appealing and therefore suitable as flagship species for certain nature types.

Box 1 Major feeding trait groups and associated microhabitats of 55 threatened Danish hoverfly species

Saprophages - 28 species

Feeding on/in decaying wood, sap runs, tree holes, etc. (xylobiontic)

- Critically endangered 1
- Endangered 9
- Vulnerable 6

Feeding in small water bodies and not on dead wood (aquatic)

- Critically endangered 2
- Endangered 6
- Vulnerable 4

Zoophages - 18 species

Feeding on other organisms, mainly aphids

- Critically endangered 2
- Endangered 7
- Vulnerable 9

Phytophages - 9 species

Feeding on bulbs and roots

- Vulnerable 5

Feeding on stems, leaves and fungi

- Endangered 2
- Vulnerable 2

IMPORTANCE OF HOVERFLIES

The importance of hoverflies can be summarised from IUCN SSC HSG/CPSG (2022) as follows: Hoverflies are the most important pollinator group together with native bees. Some wildflowers are almost exclusively hoverfly pollinated. They generally ensure better pollination than bees at higher altitudes, under Nordic climatic conditions, or in cool microclimates. Hoverflies visit at least 52% of 105 animal pollinated crop plants (estimated to be worth around US$300 billion per

[1] The report contains several boxed quotes made by the participants during the workshops.

year) and over 70% of animal pollinated wildflowers (Doyle et al., 2020). However, their contributions to healthy ecosystems extend beyond simple pollinator services to roles in biocontrol, water purification (by filter-feeding aquatic saprophagous larvae), and long-distance pollen transfer. Adults feature in the diets of insectivorous birds, spiders, ants, solitary wasps, dragonflies, robber flies and even carnivorous plants. Many parasitic wasps lay their eggs in hoverfly larvae. Many species have aphid-feeding larvae that can protect crops by keeping aphid levels at much lower levels than without hoverflies. In addition, hoverfly larvae have an important role in the natural decomposition of materials such as dead wood, compost, dung, and rotting aquatic vegetation, and can be used to decompose organic material from agricultural and industrial processes. Their wide distribution and varied larval requirements make hoverflies good bioindicators.

HABITATS AND MICROHABITATS

The threatened Danish hoverflies species are associated with both terrestrial and aquatic macrohabitats (see figure 1): deciduous or mixed forests (including forest clearings), calcareous and acidic nutrient-poor fresh meadows, wet heaths, raised bogs, calcareous grasslands, salt marshes and dynamic coastal dunes, gardens, parks and grasslands, coastal and clear-water lakes and narrow streams and springs. Adult hoverflies depend on diverse sources of nectar and the forest-dwelling species like to seek out flowers in forest clearings. However, to support hoverflies, these macrohabitats also need to offer the required microhabitat features. Hoverflies have a rich diversity in larval microhabitats and feeding traits (see box 1).

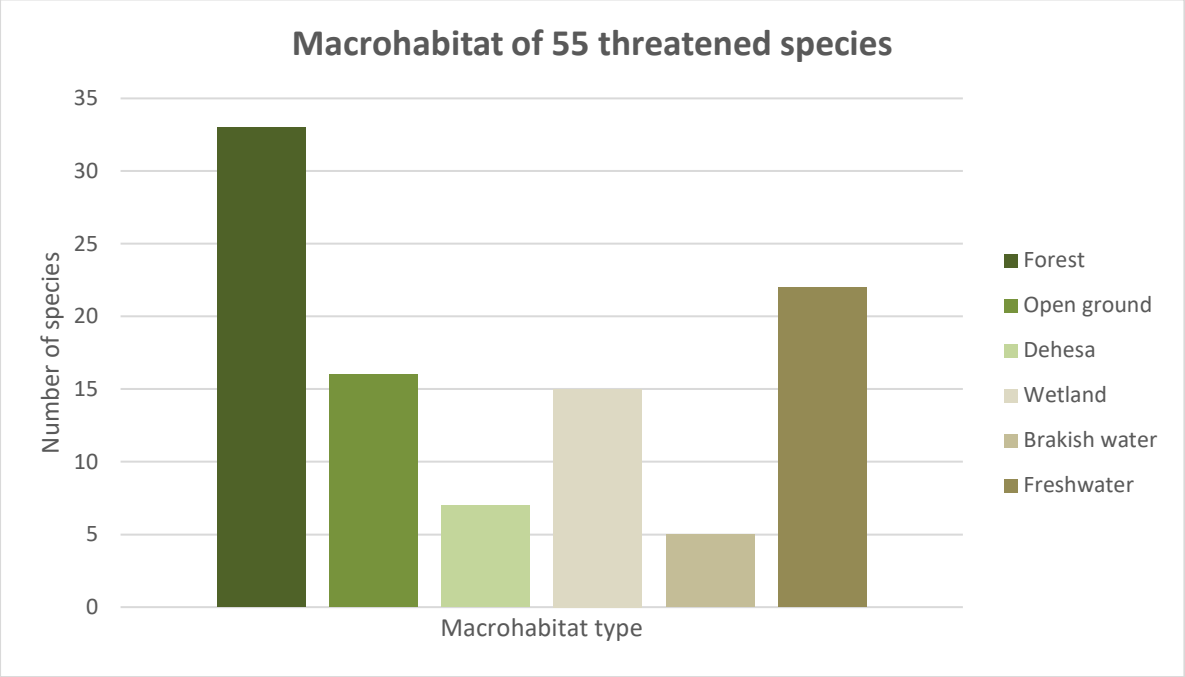


Figure 1. Distribution of macrohabitats utilised by the Danish threatened hoverfly species (Speight and Castella, 2020). One species can be associated with more than one macrohabitat. Dehasa is a landscape type characteristic for the Iberian Peninsula. It is thus not present in Denmark, but it is used by some Danish threatened species that can also occur in that region of Europe. In Denmark these species are associated with forest and open ground.

Using information on larval feeding traits from StN, the 55 species were assigned to three larval feeding trait groups (see box 1). Twenty-eight species are 'saprophagous' meaning their larvae obtain nutrients by consuming decomposing plant or animal material (see figure 2). These species depend

mostly on decaying wood, tree holes, sap runs, etc. (features often associated with (over)mature trees, stressed younger trees, fallen timber or tree stumps), or small water bodies associated with water-saturated ground, submerged sediment and water plants. Seventeen of the threatened species were grouped as 'zoophagous' with larvae feeding on living animals, predominantly aphids (see figure 3). Most of these species (and their prey) depend on microhabitats associated with trees and the herb layer. The last 9 species were classed as 'phytophagous' with larvae that are herbivorous and feed on the tissues of living, non-woody plants: bulbs and roots (5 species) or stems, leaves and fungi (4 species), and thus depend mostly on microhabitats in the root zone and herb layer (see figure 4).

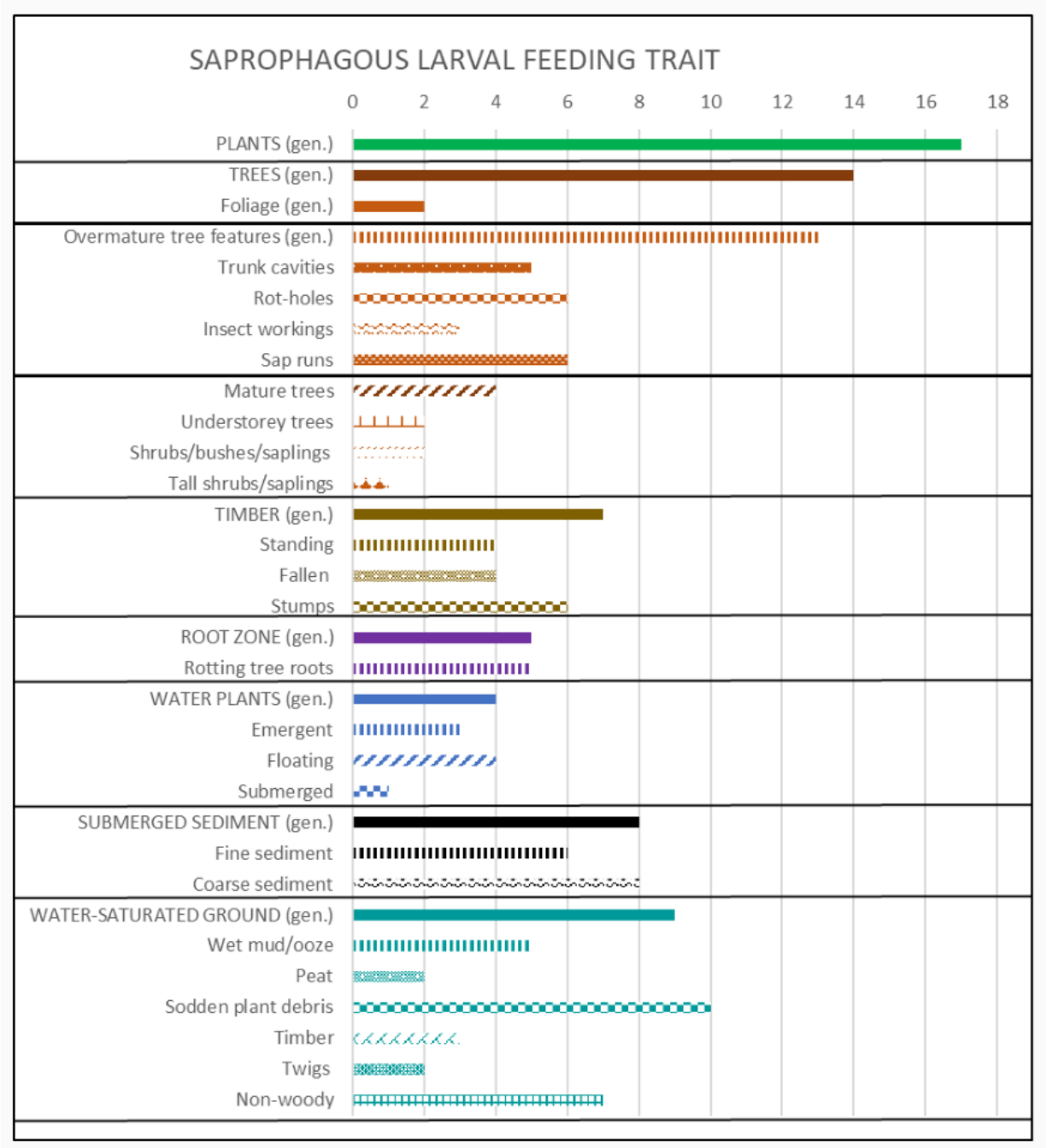


Figure 2. Number of threatened species with saprophagous larval feeding traits associated with each of the microhabitat types shown. The abbreviation "(gen.)" stands for in general; referring to a general category also treated as two or more sub-categories. See Speight & Castella (2020) for further details.

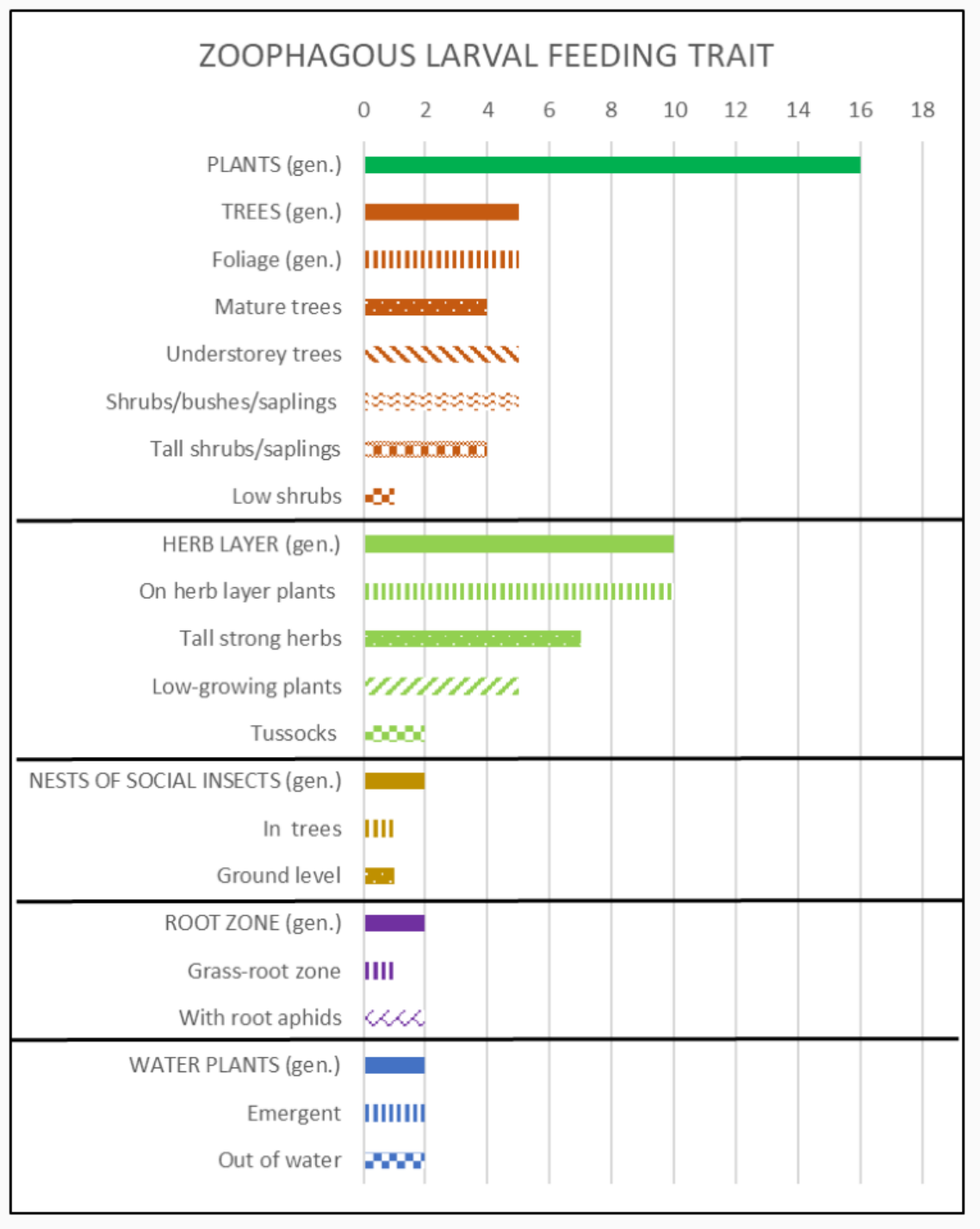


Figure 3. Number of threatened species with zoophagous larval feeding traits associated with each of the microhabitat types shown. The abbreviation "(gen.)" stands for in general; referring to a general category also treated as two or more sub-categories. See Speight & Castella (2020) for further details.

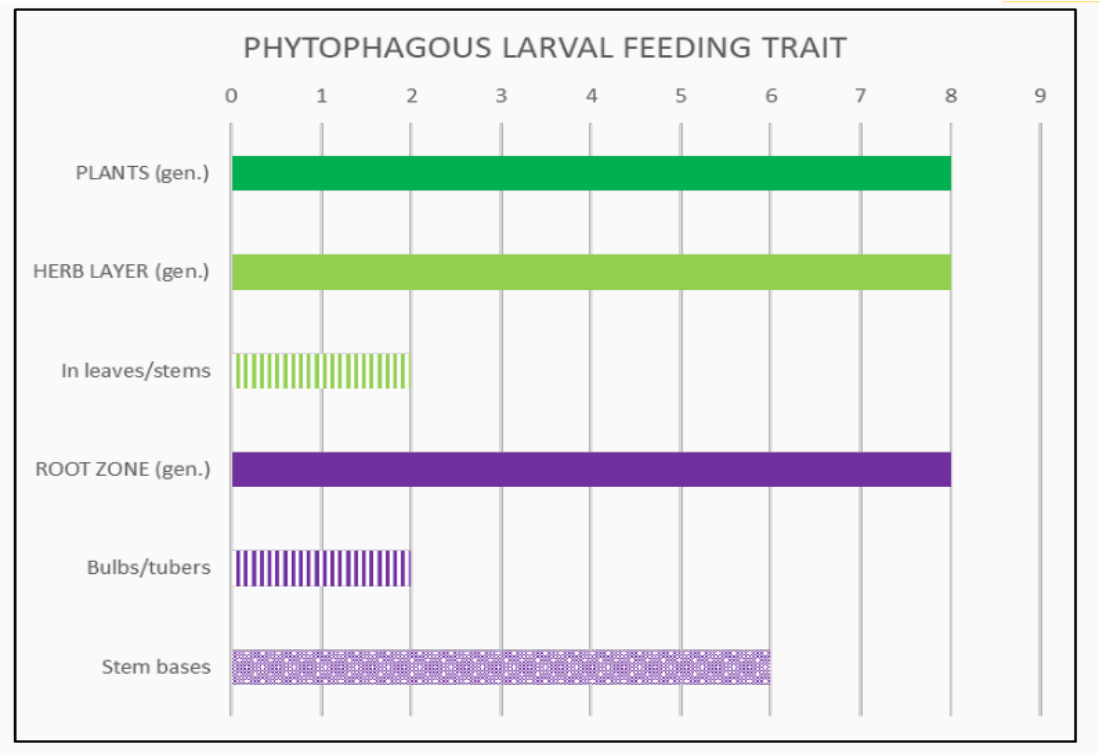


Figure 4. Number of threatened species with phytophagous larval feeding traits associated with each of the microhabitat types shown. The abbreviation "(gen.)" stands for in general; referring to a general category also treated as two or more sub-categories. See Speight & Castella (2020) for further details.

Threats

Given the importance of a large diversity of microhabitats for hoverflies, the loss of these for larvae, adults or their food constituted an important category of threats and included the loss and degradation of veteran tree features, the loss of diverse herb layers in various macrohabitats, loss and degradation of small water bodies and water-saturated ground, and the loss and connectivity of habitat mosaics. In addition to these threats, pesticide use in or near their habitat can cause direct mortality or reduced fitness in hoverflies themselves as well as the prey of zoophagous species. Pesticide use can also cause trophic/ecosystem service changes and may thus also affect hoverflies indirectly by changing the habitat or the foraging resources that they rely on.

Finally, commercial honey bee keeping could pose a threat to hoverflies through competition, though there is currently insufficient understanding whether and to what degree there is overlap in food niches. Important additional challenges to hoverfly conservation centred around inappropriate effects of, or contradictions in, policies and incentive schemes; the lack of awareness in many sectors of society about the importance of 'messy nature' (complex microhabitat structures) and about hoverflies themselves and their role as pollinators; some gaps or needs for adjustments regarding tools, databases and experts for monitoring hoverflies in Denmark; and a need to fill essential knowledge gaps in the species' biology, needs, threats and challenges.

With the historically loss of habitats in Denmark, many populations of hoverflies are today small, isolated and sensitive to stochastic events, for example changes in weather conditions.

CONSERVING HOVERFLIES IN DENMARK

Taking account of the information on the natural history, macro- and microhabitats, and threats to threatened Danish hoverflies presented in the Red List and the Syrph the Net database, the contributors to the project added their own expertise during facilitated online and in-person workshop sessions to:

- perform a threat analysis on which dynamics lie at the cause of the threats, and how exactly do the threats impact the hoverflies;
- describe the change one would like to see in ~10 years (identifying goals);
- identify lines of work (objectives) that can lead to this desired state, as well as potential obstacles that might impede progress;
- formulate recommended actions to be taken in ~10 years to implement lines of work and overcome obstacles, in order to reach the goals.

BOX 2 The identified goals for hoverfly conservation in Denmark

GOAL 1 Old and veteran trees, and their features, are valued and protected.

GOAL 2 Forest management supports hoverflies.

GOAL 3 There is a diverse herb layer in open areas as well as forests — and ecotones between them.

GOAL 4 Dune systems are dynamic and biodiverse.

GOAL 5 Natural hydrology is protected or restored — especially small water bodies and water-saturated ground.

GOAL 6 Pesticide use is rare and carefully targeted.

GOAL 7 Any commercial beekeeping practices in Denmark are compatible with hoverfly conservation efforts.

GOAL 8 There are sufficient tools, data, databases and experts for effective hoverfly monitoring and conservation in Denmark.

GOAL 9 Relevant sectors of society know what hoverflies are and are aware of their ecological value, conservation needs, and what they can do to help conserve them.

Most of these goals aim to ensure the continued existence of the very diverse microhabitats upon which hoverflies and especially their larvae depend, and the availability of sufficient and sufficiently diverse nectar and pollen sources for the adults. Pesticide management is important to ensure adequate survival of both the hoverflies and the prey of zoophagous hoverflies. Effective monitoring and other scientific work on hoverflies is vital to continue to provide a solid science foundation to guide future conservation work, as well as to evaluate the effect of implemented recommendations. Finally, despite a welcome increase in communication and awareness raising about pollinators and their conservation needs, hoverflies tend to be much less known than many other pollinator groups -

despite many being easy to observe and having striking appearances - and have additional/different requirements for example in terms of microhabitats. This requires additions to and adjustments in awareness raising.

> *"We need larger areas devoted to nature, free of commercial forestry and agriculture, with natural hydrology and grazing."*

The sections below highlight for each goal, what the issues and threat dynamics are in this field, how they affect hoverflies, and which kinds of work lines and activities are recommended in order to reach the goal. Table 1 presents a listing of a number of concrete objectives and recommended actions that the group formulated for each goal. As this work is the subject of a pilot project, the analyses and recommendations generated should be considered the best advice from the stakeholder group involved, rather than the official viewpoint or plan of action from the Danish Environmental Protection Agency (Miljøstyrelsen – MST), nor do they present MST's workplan or funding commitments. As stated previously, the aim of this project was to showcase a methodology for moving species from assessment to multispecies planning.

This plan's recommendations for Danish hoverfly conservation are science based and compiled by experts and representatives from multiple stakeholder groups. They are intended to give direction to the audience groups for this plan (see section 'The Pilot Project' above) as to what they can do to improve hoverfly conservation in Denmark. In addition, measures recommended in this plan, if implemented, would benefit not only hoverflies, but also other pollinator groups and invertebrates performing vital functions in the Danish landscape.

GOAL 1: OLD AND VETERAN TREES, AND THEIR FEATURES, ARE VALUED AND PROTECTED

"A tree with wounds and dead parts is not just a half-dead tree but an important source of life."

IMPORTANCE TO HOVERFLIES

The larvae of especially the xylobiontic saprophagous hoverflies feed on or in decaying wood, sap runs, rot-holes, trunk cavities, tree stumps, fallen/windblown timber etc. (see 'Habitats and microhabitats' above) and are thus dependent on these features which are found in old, overmature "veteran" trees but potentially also on stressed or damaged younger trees.

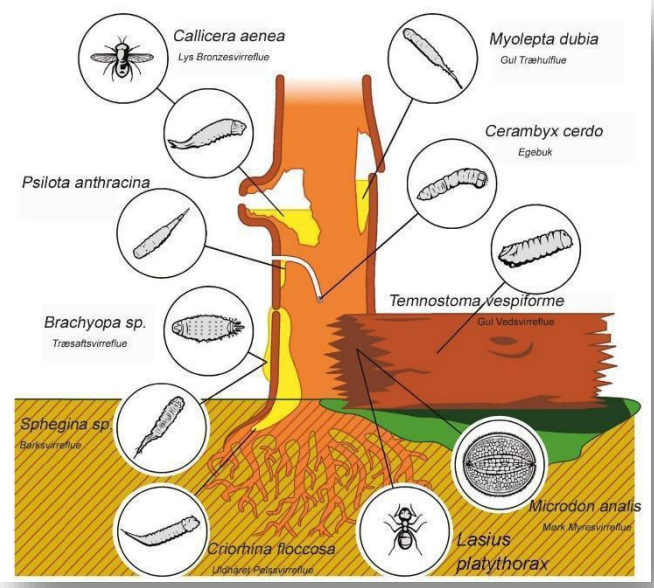


Figure 5 Old living trees with rot-holes, sap runs etc. are more important to hoverfly larvae than fallen or standing dead trees. (Dziock. 2006), © 2006 Julius Luge.

THREATS AND CHALLENGES

In Denmark, veteran tree features are declining in several ways. These can be broadly categorised as: the loss of entire veteran trees across the landscape; and the loss or absence of forestry practices that support veteran tree habitats. The main pathways through which this occurs are described below. Yet, in certain places old growth and veteran trees are safeguarded and valued, both for their ecological and aesthetic value. In addition, in recent years many initiatives have been taken to actively veteranise younger trees or prolong the life of existing veteran trees (see Continuity issues below).

LOSS OF ENTIRE VETERAN TREES ACROSS THE LANDSCAPE

Veteran trees continue to be lost across the Danish landscape due to the challenges outlined below.

LACK OF KNOWLEDGE AND GENERAL PERCEPTIONS

The value of old and veteranised trees to biodiversity is not well-recognised. Farmers often consider them ugly and untidy and so tend towards tidying them up. They are not seen or protected as important habitats other than in some cases for bats and birds.

High prices for biomass

Veteran trees that are associated with old hedgerows/fence lines made of earth banks, stone walls and associated vegetation, are being lost. High prices for biomass have led to many of these fence lines being taken down and sold for the furnace, often by entrepreneurs who may not understand the value of old or veteranised trees. Big trees (with greater biomass) generate the biggest returns and so can be a target. Where these fence lines are of heritage value, they carry legal protections administered through the Ministry of Arts and Culture. However, the protection covers only the earth banks and stone walls and not the associated trees and other vegetation.

Figure 6 As a tree ages, parts of it become diseased or damaged, providing habitats which saproxylic organisms can colonise. Examples of such habitats are marked in solid black on the figure (Speight 1989).

Public safety concerns

In parks and other public spaces such as along roads and paths, old trees may be cut or removed to prevent risks to the public.

Behavioural challenges

Establishing effective measures to protect solitary old trees in the landscape can be difficult as landowners and managers may prefer to cut trees before they are old enough to receive formal protection.

Absence of legal protection or incentives

There is currently no legal protection of old trees in Denmark. There is a subsidy scheme for protecting single-standing trees, administered by the Department of Agriculture, but the subsidy is low, and the scheme is complicated, with a need to reapply annually.

Old trees may require special management and pruning to extend life and reduce risks to people. These methods require specialist skills that are rare in Denmark where there is little tradition of managing veteran trees. There are some companies that provide this expertise, but it is expensive and so not often done. Within private forestry, the grant scheme available in Denmark does not provide enough incentive to drive more of this work.

Loss or absence of forestry practices that support veteran tree habitats

Continuity issues

Half of the forest in Denmark is young, that is, less than 50 years old. Maintaining old-tree features until the younger trees become naturally veteranised is difficult because of the length of time required. Supporting the short-term continuity of veteran tree features requires deliberate injury to younger trees so that they develop the required features prematurely. This can be challenging both in

terms of practice and perception, as injuring trees often tends to be negatively perceived. Yet, in recent years many initiatives have been taken to actively veteranise younger trees and manage for prolonging the life of existing veteran trees. Examples include work by private nature conservation organisations and in state forests, e.g. via the EU co-financed project LIFE Open Woods (https://naturstyrelsen.dk/naturbeskyttelse/naturprojekter/life-open-woods/).

In production forests, the focus is on high-value trees. When thinning, there is selection for trees that grow straight and without flaws – that is, foresters take out the trees likely to develop the veteran tree features that are of value to species such as hoverflies. Similarly, traditionalists do not harm the standing trees when felling. Landowners may be willing to fell a tree for firewood or other purposes but can be averse to damaging a living tree deliberately.

> *"If necessary, take the branch not the tree."*

Removal of dead wood

"Traditionally, felled old trees are removed to avoid disease spread, which reduces the amount of dead wood habitat available. There is ongoing discussion about the magnitude of this risk. In recent years, the practice has changed, both in some privately owned and in general in state-owned forests (currently about 18% of forest in Denmark)."

Lack of expertise

Many privately owned forests are small – less than 10 hectares. Many owners have just one small patch which they may have inherited or acquired for hunting or other recreational use. They are not generally trained in forest management, and though some may have knowledgeable consultants, not all do.

Veteran tree in forest glade, Klosterskov (Denmark). Photo © Jonas Morsing Thomasen.

WHAT IS NEEDED FOR THE FUTURE

To ensure sufficient presence of veteran tree features, three themes of work are proposed:

- Recognise and promote veteran trees and their features as important habitats.
  In policies, and in the minds of landowners, foresters, and citizens with gardens hosting old trees, veteran trees should be valued for providing key habitats for important elements of Danish biodiversity, including threatened Danish hoverfly species. Landowners, foresters and private citizens should be encouraged and supported to protect, manage and create these habitats.
- Increase the protection of individual veteran trees.
  Veteran trees and their features should receive greater protection on old fence lines and earth banks, and in hedgerows. In addition, changes should be made to public safety laws and to policy and certification schemes, to support and incentivise protection of individual veteran trees.
- Ensure that the next generation of veteran trees is present and protected at biodiversity hotspots.
  Preventing or mitigating a 'generation gap' in the availability of veteran tree habitats should be addressed through, for example, planting shorter-lived trees that veteranise quickly, veteranising trees by damaging them, and planting new forests in hotspots of saproxylic invertebrates, including hoverflies, using quickly veteranising trees and/or practising veteranisation.

Note that appropriate levels of grazing in forests can also help veteranise trees (see recommended action 2.1.3 in Table 1 (Section: Table of Goals, Objectives and Actions)).

GOAL 2: FOREST MANAGEMENT SUPPORTS HOVERFLIES

IMPORTANCE TO HOVERFLIES

Forests are an important habitat for a number of hoverfly species, both as larvae and as adults. If the forest is to be an optimal habitat, it must contain a good mix of parameters such as old trees of different species, dead wood, natural hydrology and flowering trees and shrubs.

The larvae typically live and feed in/on plants, in trunks with rotten parts, sap runs, in fungi, in bogs and streams, etc. Many zoophagous species (and their prey) also depend on microhabitats associated with trees and the herb layer. Some of the hoverfly species that live in dead, dying or damaged/veteranised wood/trees are rare and distributionally limited to natural forest sites with veteran tree features and long continuity. Together with other hoverflies, they are indicator species for valuable habitats.

Adult hoverflies feed mainly on pollen and nectar. Therefore, wildflowers and different flowering trees and shrubs that flower at different times are important in both the forest and the open landscape. A good mix of mirabelle, apple, elder, hawthorn, rowan etc., which all bloom at different times, provides good conditions not only for hoverflies, but for all pollinators.

A relatively high humidity is optimum for hoverflies and they seek shade on hot and sunny days. Small water bodies and water-saturated ground in forests provide cooler air temperatures and help maintain humidity and dead wood in damp conditions, which is the preferred microhabitat of many hoverfly species. See Goal 5.

"Old-style coppicing is a forestry practice that can have high biodiversity value through promoting veteran tree features."

THREATS AND CHALLENGES

Old forests often provide various microhabitats, including veteran trees and small water bodies and water-saturated soils, whereas afforestation can ensure these habitats' existence and better connectivity into the future.

At the beginning of the 19th century, forests covered only a few percent of the Danish area. Since then, the forest area has grown to approximately 15%. This means that about half of the forest area is classified as "young forest" being less than 100 years old, which significantly reduces the potential for veteran trees — unless the trees are actively manually veteranised. In addition, the majority of the forests were planted with wood and biomass supply and optimisation in mind, which has meant less species variation and drainage of the soil. The optimisation has also meant the removal of dead wood and denser forests, which allow less sunlight to reach the forest floor and thus reduce the forest floor flora. Historically, there has also been a sharp distinction between forest and open land, meaning loss of ecotones.

DATA, MAPPING AND CERTIFICATION

There are many small habitats with valuable nature for the benefit of hoverflies in Danish forests, private as well as state forests. Many private forest owners voluntarily wish to set aside parts of their

forest for biodiversity purposes. Private forests contain a lot of areas suitable to be left unmanaged, and in most cases, they are left unmanaged because they have a low productivity value. These areas often have a high biological value, the so-called §25 areas (Skovloven §25).

Veteran tree surrounded by blooming bushes, Biskops Arnö, Sweden. Photo © Jonas Morsing Thomasen.

However, an overview of the areas is lacking. It is therefore positive that valuable habitats have been mapped in the state forests, and mapping of the §25 areas has started in the private forests. In the long term, the mapping helps inform management plans and subsidy schemes and should help preserve the valuable areas.

Mapping of valuable habitats can also make it easier for forest owners to certify the forests. Certification requires, among other things, that a minimum of 10% of the forest area is left for biodiversity purposes, and a certain amount of wood is left in the forest for natural death and decay.

SUBSIDIES AND SCHEMES

Parts of the private forests are designated for biodiversity purposes and are protected through agreed obligations. This is primarily ensured through subsidy schemes, for example subsidies for unmanaged forest and other biodiversity forest.

In order for more forest owners to make use of the subsidy schemes, however, there is a need for the schemes to be adapted so that they adequately support the objectives of the plans. The subsidy schemes are often characterised by bureaucracy, which does not make it attractive for forest owners to apply. Many private forest owners would like to leave their forest unmanaged voluntarily, if they think their areas are suitable and qualified.

LACK OF KNOWLEDGE

Many Danish forests are small (less than 10 ha) and fragmented and have hunting and pleasure as their primary purposes. The forest owners are typically not educated within forestry and potentially only moderately aware of the biological values of old trees and other structures/environmental parameters that support hoverflies and other insects. Synergies can be found in the management between hunting interests and hoverflies, for example making small water bodies and planting flowering trees and shrubs. There is an overall need to increase the knowledge and awareness of hoverflies among landowners as well as forest contractors and consultants in order to manage in a hoverfly-friendly way.

WHAT IS NEEDED FOR THE FUTURE

To ensure that forest management supports hoverflies, three themes of work are proposed:

- Ensure adequate habitat for larvae (see objective 2.1 in appendix 1).
  A higher diversity of species composition and age in productive stands of trees is needed to ensure presence and continuity of larval habitat, together with a diverse, healthy herb layer and the maintenance of natural hydrology. Ensuring the presence of small water bodies and water-saturated ground in forests is critical (see Goal 5) for helping to maintain dead wood in damp conditions, which is the preferred microhabitat of many hoverfly species. Forests should be grazed at appropriate levels, to create open areas and ecotones, to help disperse seed, and to help veteranise trees.
- Ensure adequate habitat for adults (see objective 2.2 in appendix 1).
  Forests should be actively planted for a diverse herb layer, especially when converting production forest to nature. Whenever forests are replanted, hotspots with microhabitats for larvae should be identified and protected. A mix of tree species should be present, that provide good nectar and pollen sources for adult hoverflies. For example, a mix of elderflower, crab apple, blackthorn, hawthorn, rowan and willow will provide resources throughout the season. Meanwhile, weeding should be stopped or kept to a minimum. With regard to afforestation, particularly with public funding, there is potential in creating criteria/parameters that create macro- and microhabitats beneficial to hoverflies (and other invertebrates). Requirements dealing with the variety of tree species, the planting of flowering shrubs and trees, and the maintenance of natural hydrology would be of benefit to hoverflies.
- Ensure awareness of the benefits of managing forests for hoverflies.
  There should be greater awareness among landowners on managing forests for attracting insects (including hoverflies) to benefit from the services that they provide, e.g. pest control.

Goal 3: There is a Diverse Herb Layer in Open Areas as well as Forests - and Ecotones between them

Importance to hoverflies

A herb layer is dominated by herbaceous plants such as wildflowers and is important for hoverflies. In their adult life stage, they rely on a diverse range of flowering plants to forage on. To target both early- and late-flying species, flowers must occur from early spring to late autumn. Therefore, the protection, restoration and establishment of flower-rich habitats is of vital importance to hoverflies. Furthermore, certain genera, such as *Merodon* (bee-like hoverflies; in Danish Narcisfluer) and *Eumerus* (blackish hoverflies; in Danish Løgsvirrefluer), mostly rely on bulbous plants as food plants in the larval stage. The food plant of *Eumerus sabulonum* is *Jasione montana* (Blåmunke), and the food plant of some of species is unknown.

Hoverflies occur in both open and woody habitats, as well as the transitional zones (ecotones) between such habitats. Therefore, it is important to maintain abundant flowering resources across a wide ecotone: From open meadows, heaths and bogs to forest edges and clearings within the forest itself.

Although some hoverflies will visit cultivated flowers in gardens or agri-environmental schemes, native plant species are of a much higher value for hoverflies - and wild pollinators in general. Therefore, the main focus should be on increasing native flower abundance in their natural habitat.

Threats and challenges

The presence of flower resources has decreased drastically in both open and woody habitats due to intensification of forestry and agriculture and lack of extensive grazing. Furthermore, ecotones between open and woody habitats, which are particularly rich in resources for hoverflies, have gradually been lost. The main factors to address these issues are described below.

Loss of flower-rich habitats

Due to agricultural intensification, many open habitats such as meadows, heaths, coastal dunes and bogs have gradually been converted into farmland or plantations. Around the year 1800, open habitats covered more than 25% of Denmark, but currently this is only ~10% of the land area. The loss of these habitats has had a strongly detrimental effect on the many species of pollinators - including hoverflies - which relied on these flower-rich habitats for either parts or the entirety of their life cycle. One example is *Cheilosia antiqua* (Kodriver-urtesvirreflue) which is assessed as Vulnerable (VU). The larvae live in the stems of certain *Primula* species, which only occur in old, undisturbed woodland and/or grassland. The species therefore relies on large and stable populations of *Primula*, which today are scarce.

> *"Mowing generates poorer biodiversity outcomes than grazing."*

Lack of grazing

Grazing is probably the most essential process to maintain flower-rich habitats across the whole ecotone from open to woody habitats. Through their grazing, browsing and disturbance of the soil,

horses and cattle maintain open habitats, where flowering plants may thrive - thereby indirectly benefiting not only wild pollinators such as hoverflies, but a whole suite of other species.
Wild grazing animals such as bison, deer, wild cattle, wild horse and wild boar have occurred naturally in our landscapes for thousands of years, thus contributing to the development of species-rich habitats. However, these wild species have gradually been replaced by livestock such as cattle, horses, sheep, goats and pigs. In 1900 there were more than 515,000 horses and 2.3 million cattle on Danish farms, contributing to year-round grazing of the landscape. Today, only a tiny fraction of this number of livestock remains, of which most are kept stabled for most of their life.

Due to this development, both open and woody habitats have gradually lost their importance for grazing and/or haymaking. Today it is estimated that more than 80% of open habitats are left un-grazed, leading to detrimental effects on biodiversity as a whole. Furthermore, grazing in woody habitats has been prohibited due to the intensification of forestry. It is therefore of vital importance for hoverflies to restore low-intensity grazing in as many habitats as possible.

Flowering meadow, Møgelskår (Denmark). Photo © Anne Eskildsen (2020).

LACK OF NATURAL GRAZING - INAPPROPRIATE GRAZING LEVELS FOR HOVERFLY AND BIODIVERSITY CONSERVATION

Fløjgaard et al. (2021) found that the natural grazing pressure for Danish habitats lies between 70-250 kilos of grazing animals per hectare. For very highly productive systems up to 300 kg/ha may be suitable. This grazing pressure is set according to the food availability during the winter period, so grazing may be supported throughout the year, and not only during the summer months. A grazing pressure within this range - and preferably throughout the year - will contribute significantly to supporting biodiversity.

However, grazing pressure in unfenced areas, where only free-ranging deer occur, is estimated to be as low as approximately 5 kg/ha, while the average grazing pressure in fenced natural areas, grazed by livestock, is over 600 kg/ha (Fløjgaard et al. 2021).

Both scenarios are detrimental for hoverflies, as insufficient grazing will result in gradual overgrowing, while overgrazing will result in low availability of valuable pollen, nectar, and larval food resources. Overgrazing may also affect plants used by aphids and thus affect zoophagous larvae. It is therefore important to create incentives for livestock-owners (i) to establish grazing of natural areas, which are not currently grazed, so the grazing pressure can be increased where it is currently too low and (ii) to create legislation to avoid overgrazing of natural areas of high value for hoverflies and biodiversity in general (see below).

LACK OF INCENTIVE FOR MANAGEMENT PRACTICES THAT SUPPORT FLOWER-RICH HABITATS

Track in grazing area, Mariager (Denmark).
Photo © Anne Eskildsen

A whole suite of agri-environmental subsidy schemes and legislation currently affects how grazing is applied in our landscape. Each year, 180 million DKK are paid to farmers through grazing subsidies. Despite this large annual sum, and the intention for these subsidies to support biodiversity, this has not resulted in positive effects on the conservation status of hoverflies or biodiversity in general.

The current subsidy schemes do not focus on incentivizing a low grazing pressure and a long grazing season, even though these actions are known to be beneficial for biodiversity. Therefore, intensive summer grazing continues to be the predominant management form on most valuable natural areas.

Furthermore, there are no current schemes which support the creation of new, permanent flower-rich habitats through conversion of agricultural land into nature.

LACK OF FOREST GRAZING

Grazing is a natural process in woodland habitats and essential for the creation and maintenance of habitats for hoverflies. Grazing animals such as horses, cattle, goats, or deer all help to create and maintain warm and sunny patches/clearings within the woods. These open spaces support a diverse flora and a warm microclimate, making them exceptionally important as habitats for hoverflies as well as many other insects.

However, in Danish legislation grazing in woodlands is prohibited. It is possible to apply for a grazing dispensation in forests, but the process is slow and often met with a denial. If permission is given, it is

often temporary or followed with strict demands that the cattle and/or horses do not damage trees. This is extremely counterproductive for biodiversity.

LOSS OF ECOTONES

Ecotones, i.e. transitional zones between open and woodland habitats, are of critical importance for hoverflies, as they contain a very rich diversity of habitats and resources. However, natural ecotones have been all but lost in the Danish landscape. This loss may be ascribed to the fact that habitat management in Denmark traditionally has either focused on open habitats or woody habitats, but not the transitional zones between these habitats. For instance, it is not possible to obtain grazing subsidies for both woody and open habitats within the same fence, therefore encouraging landowners to separate and manage them individually.

The creation and enhancement of ecotones may therefore be supported by encouraging new management strategies, that allow i.e. grazing across open and woody habitats.

STRONGER INCENTIVE FOR MOWING THAN GRAZING

Management of natural habitats such as meadows or heaths by mowing has very inferior or even detrimental effects for hoverflies compared to grazing, as important nectar, pollen or larval food resources are removed during a critical time. Overgrazing may also affect plants used by aphids and thus affect zoophagous larvae. It is therefore important to provide incentives that support grazing over mowing wherever possible. However, the new Common Agricultural Policy (CAP) will bring new incentives that favour mowing over grazing. It is therefore feared that many farmers may replace grazing with mowing, due to economic reasons.

PUBLIC PERCEPTION OF GRAZING

As grazing animals have slowly disappeared from the landscape, the public's perception of grazing as an important and natural process has changed. Today, many people are not used to handling livestock, and may feel uncomfortable in meeting free-ranging cattle or horses when visiting natural areas. It is therefore important to focus on how to increase public awareness of the importance of grazing for hoverflies - and biodiversity in general - and how to handle close encounters with livestock safely.

LOSS OF NATURAL PROCESSES WHICH CREATE, SUPPORT OR ENHANCE FLOWER-RICH HABITATS

Apart from grazing, natural fire regimes, natural hydrology, natural coastal dynamics, and wind felling (through storms, bark beetles, strong winds) can all support the presence and continuity of biodiverse landscapes and the presence of ecotones between habitats. However, all of these processes are inhibited by humans. It is therefore important to let these natural processes take place without human interference, wherever it is possible and not very detrimental to humans and their livelihood and safety.

WHAT IS NEEDED FOR THE FUTURE

To ensure a diverse herb layer in open areas as well as in forests, and ecotones between them, four themes of work are proposed:

- Promote grazing over mowing.
  Land managers should be supported and incentivised to use grazing instead of mowing, ideally with a mix of species, as it creates the ecotones and microhabitat diversity important to many Danish species, including hoverflies.
- Optimise the benefits to farmers of subsidies related to grazing regimes to benefit/conserve biodiversity.
  To optimise biodiversity outcomes, grazing subsidy schemes should take a science-based approach to setting grazing levels to ensure they are appropriate to the site or habitat type.
- Change public perceptions about grazing in natural landscapes.
  In Denmark, grazing should be valued as a natural process, with grazing animals seen as an important part of the landscape.
- Support the presence and continuity of ecotones.
  In addition to extensive grazing, natural fire regimes, natural hydrology, natural coastal dynamics, and wind felling (through storms and strong winds), should all be supported to proceed naturally wherever possible, as these events all support the presence and continuity of ecotones and should be valued as important natural processes that bring biodiversity benefits. Habitat connectivity should be valued and promoted to facilitate natural movement of hoverflies and other biodiversity elements. Where it cannot be maintained or restored, consider using translocation.

GOAL 4: DUNE SYSTEMS ARE DYNAMIC AND BIODIVERSE

IMPORTANCE TO HOVERFLIES

Denmark holds 10% of Europe's dune area and 80% of coastal meadows and salt marshes. It is among the most dynamic nature in Denmark and makes an important contribution to European biodiversity.

Most hoverflies species in dunes and dune plantations are xerophilic and prefer open areas sheltered by scrub or planted pine trees. The species are dependent on larval food being available, which again is dependent on low to medium nutrient levels. Known larvae of threatened species in dunes and dune plantations are zoophagous, saprophagous and phytophagous. Some hoverflies are associated with salt marshes, coastal meadows, lagoons and wetlands.

> *"Denmark's coastal meadows will be gone in 30-50 years because they don't have any room to move."*

EXAMPLES OF HOVERFLY SPECIES IN DUNES AND DUNE PLANTATIONS

Paragus tibialis (Klit-maskesvirreflue) is assessed as Endangered (EN). It requires open ground, dry heathland and glades in dry pine forests. Larvae feed on aphids on various plants.

Sandy location with *Pelecocera lusitanica*. Photo © Leif Bloss Carstensen (2022).

Eristalis oestracea (Bremse-dyndflue) is assessed as Critically Endangered (CR). It requires oligotrophic/mesotrophic water bodies in bog, moor and coastal dunes. The larva is unknown, but likely feeding on micro-organisms in water with decomposing plant or animal material.

Pelecocera lusitanica (Dværg-svirreflue) is assessed as Endangered (EN). It requires sandy locations with pine. Larvae feed on fruit bodies of *Rhizopogon obtextus* (Gul skægtrøffel/Yellow False Truffle) which depends on pine.

Example of hoverfly species in coastal meadows, salt marshes and brackish water

Lejops vittata (Kogleaks-damsvirreflue/Dyke Hoverfly) is assessed as Vulnerable (VU). It is known from coastal sites with stands of *Bolboschoenus maritimus* (Strand-Kogleaks/Sea Club-rush). The larva is aquatic and feeds on dead organic material.

Threats and challenges

The main threat to dune systems is eutrophication causing open areas to be overgrown by grass and scrub. This is also a threat to oligotrophic and mesotrophic water bodies. In addition to eutrophication, coastal meadows and salt marshes are threatened by rising sea levels.

Some hoverflies need brackish water. In some areas the water is drained or the area overgrown. There are no longer many landscapes where tidal water is allowed inland, and so salty landscapes are limited. These areas have been turned into agricultural land – a high priority in Denmark.

Favourite "activity" of *P. lusitanica* - resting. Photo © Leif Bloss Carstensen (2022).

Eutrophication

Eutrophication is mainly caused by intensive animal husbandry, via manure and airborne ammonia, and results in a predominance of grass and tall plants, which outcompete less competitive plants and fungi. This reduces plant and fungus diversity, and thus the abundance of larval food. See also Goal 5.

Microhabitats associated with oligotrophic and mesotrophic pools and small water bodies in open habitats are damaged through eutrophication. Horse droppings in connection with horse riding in vulnerable habitats contribute to the problems.

Rising sea levels

Areas with coastal meadows and salt marshes, and associated habitats, will be reduced as sea levels rise. It is therefore vital to ensure that sufficient areas inland provide suitable habitat for hoverfly species that rely on these.

Fertilisers and pesticides

Fertilisers and pesticides used in adjacent agricultural areas have a negative impact on the biodiversity, thus reducing the availability of nectar and pollen sources and larval food. See also Goal 6.

LACK OF KNOWLEDGE

Larvae of 22 out of the 55 threatened species are still unknown; the larval feeding type is inferred but the larvae have not been found yet. The knowledge of which microhabitats adult flies require is also incomplete. This lack of knowledge makes it difficult to take targeted actions aimed at specific species. For example, *Pelecocera lusitanica* (Dværg-svirreflue) is, as described above, found in sandy locations with pine and the fungus *Rhizopogon obtextus* (Gul Skægtrøffel/Yellow False Truffle). In the same locations, the other species in the genus, *P. tricincta* (Bredhorn-svirreflue/Southern Bighorn), which is common and assessed as Least Concern (LC), can be found in less sandy places just 50 to 100 metres away from the stronghold of *P. lusitanica*. It can also be found in inland locations, and the fungus is widespread in inland pine plantations. Why does *P. lusitanica* require sandy locations, whereas the fungus serving as larval food does not?

As a result of our limited knowledge, for the moment only general actions can be taken for threatened hoverflies in dunes, dune plantations and coastal lagoons.

WHAT IS NEEDED FOR THE FUTURE

To ensure that dune systems are dynamic and biodiverse, these themes of work are proposed:

- Establish year-round grazing regimes to benefit and conserve biodiversity and prevent overgrowth. This may require dispensations for the construction of shelters in areas where there is no natural shelter. Or include part of an adjacent plantation to provide shelter. Overgrazing, as well as pollution of water bodies with low nutrient levels should be prevented. See also grazing-related issues under Goal 3 above.
- Remove clippings when roadsides in plantations are mowed. This reduces the nutrient level of the soil and increases the diversity of plants serving as nectar and pollen sources.
- Investigate if horse riding and the associated droppings are a threat to the biodiversity in protected areas and consider prohibiting horse riding in vulnerable habitats.
- Ensure continuity of habitats for pine-dependent species. If mountain pine plantations are converted to plantations with non-invasive, native pine species, the conversion must be sufficiently gradual to provide continuous, sufficient habitats for reliant hoverfly populations. It includes ensuring sufficient nectar and pollen sources. See Goal 3 above.
- Acquire habitats behind existing coastal meadows and salt marshes. This may enable species requiring such habitats to move inland with rising sea level.
- Ensure fertiliser- and pesticide-free zones around dunes and dune plantations. See Goal 6 below.
- Conduct research/projects to obtain more, and more precise, data for the assessment and planning of targeted conservation actions for threatened species. For example, by searching for threatened species in locations where they once were recorded, and by enabling non-vocational hoverfly researchers through funding for petrol, accommodation, etc. to carry out further research of the microhabitats of threatened hoverflies in remote areas, such as dunes and plantations on dunes, and to find hitherto unknown larvae of threatened species. This will enable the identification of more targeted actions for the individual species. See also Goal 8.

Goal 5: Natural Hydrology is Protected or Restored — especially Small Water Bodies and Water-Saturated Ground

Importance to hoverflies

A relatively high humidity is optimum for hoverflies. If the air becomes too dry, hoverflies are less active, resulting in reduced pollination. The optimum air temperature is species dependent, usually around 20 °C, however, higher or lower for certain species. The presence of isolated ponds or lakes is often insufficient to create a humid environment. Water-saturated ground, small water bodies and natural surface water bodies (small streams, lakes, bogs, meadows and other wetlands) are important for many hoverflies.

Hoverfly species that occur in muddy waters are relatively common, whereas some of the rare species require clear water/oligotrophic (nutrient-poor) water systems, such as spring water.

Water-saturated ground also tends to produce a denser herb layer, which provides nectar and pollen sources for adult hoverflies and food for larvae of some phytophagous species.

Threats and challenges

Denmark is a relatively flat lowland, where regulation of natural hydrological conditions is widespread, e.g. through drainage ditches and water abstraction. The extensive reduction of habitat availability for species of various taxonomic groups associated with small water bodies and water-saturated grounds is thus widely recognised. The situation is relevant both in productive forests, agricultural landscapes and urban conditions. In addition, reduction of water quality and clarity through, for example, the influx of excess nutrients, may affect hoverflies directly and also impact the vegetation. Excess nutrient levels favour larger, more competitive plants, thereby both outcompeting smaller species of importance to some larvae, and/or overgrowing (i.e. "closing") the water body. The grazing level by domestic animals can be inadequate to support habitat conditions for hoverflies around water bodies.

> *"Unprotected habitat with potential to develop protected areas tends to be either abandoned or ploughed to prevent it becoming a protected area."*

Drainage

The hydrological conditions are influenced by artificial drainage in most of the Danish landscape, including natural and semi-natural areas. In general, ditch maintenance is obliged, to prevent flooding of upstream, neighbouring land. In meadows protected by the Danish Nature Protection Act (§3) ditch maintenance is allowed for ditches established before 1992. The practice influences the distribution of potential hoverfly habitats across the countryside, in terms of small water bodies and water-saturated grounds. Vegetation management via grazing or mowing, in order to obtain EU subsidies, may be a local driver of ditch maintenance.

Subsidy for hydrological restoration in Natura 2000-sites both in forest and open land has existed, but at present there is a lack of incentives for private landowners to apply. The scheme may continue with the new Natura 2000-plans as natural hydrology is prioritised in these areas.

In state forests, practice changed with the implementation of close-to-nature forestry by 2005. Since then, ditches generally are not actively maintained. Along with this, parcels were set-aside untouched, in practice often on water-saturated ground. Since then, consecutive initiatives have resulted in a shift in the main focus towards managing for biodiversity on state-owned land. This includes prioritisation of actively restoring natural hydrological conditions.

It would be beneficial to hoverflies to also reduce drainage in other forested areas, such as private production forests. It varies how intensively private forests are managed, also in relation to drainage needs. Many small areas may be relatively extensively managed, but, on the other hand, active restoration of hydrological conditions may be hindered if the potential wetland crosses cadastral boundaries. Larger estates may have more economic interests in the productive capacity, and thus maintenance of artificial drainage, but also often have areas left untouched for sentimental reasons, including wetlands.

Forest wetland with domestic grazing, Mariager (Denmark).
Photo © Anne Eskildsen.

Re-wetting forests and re-establishing small water bodies is not often seen as an important component of private forest management. One exception is the creation of isolated ponds and lakes e.g. to facilitate hunting. Such biotopes may however be insufficient to support threatened hoverflies, in terms of water quality.

Excess nutrients

Excess nutrient levels may affect hoverflies directly as well as indirectly by impacting the vegetation. Especially in topographically undulated areas with springs it is important to ensure oligotrophic conditions.

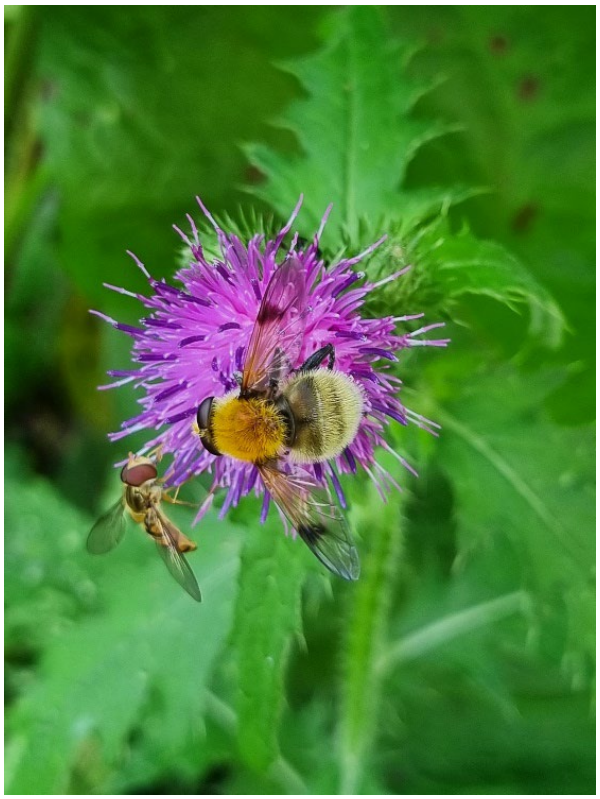
Denmark is among the world's most intensively utilised landscapes, and hereto among the largest exporters of pig meat. More than 60 % of land is in agricultural practice and around 5,000 pig farms in Denmark produce approximately 28 million pigs annually (https://agricultureandfood.dk/). The situation leads to a potentially high environmental nutrient load, where e.g. the fate of pig manure is influential on local biodiversity including hoverflies. The practice results in excess phosphate, which is otherwise unusual. Manure is required to be evenly distributed across the concerned property, which can affect small water bodies and hoverflies.

Denmark has legislation in place to protect aquatic habitats, e.g. by the Danish Nature Protection Act, and there are policy initiatives dealing with nitrate and phosphate issues. The mitigation of agricultural run-off in Denmark is considered successful in having reduced nutrient levels, and the quality of aquatic habitats has generally improved since the late 1980s. However, there is still a potential for more improvement.

INAPPROPRIATE LIVESTOCK GRAZING

In topographically varied areas with springs, ongoing grazing at appropriate levels to keep the vegetation low is required to maintain their function as hoverfly habitats. In absence of sufficient grazing, successive colonisation of tall herbs and shrubs is a threat. Conversely, overgrazing around sensitive water bodies can be equally detrimental, through both physical and chemical effects. However, an appropriate grazing regime for hoverflies may be challenged by rules and bureaucracy, e.g. in relation to subsidies. Also, the habitat may be smaller than what is economically feasible for establishing a grazing regime.

In addition to the maintenance of a favourable vegetation structure, herbivores, especially cattle, induce physical disturbance to the ground, creating small water bodies in which some hoverflies thrive. For example, the two *Arctophila* species (Bjørnesvirrefluer) use such microhabitats.



Arctophila superbiens (Brun bjørnesvirreflue), assessed as Endangered (EN) in the Danish Red List.
The other species may be a *Eristalis te*nax (Droneflue/Common Drone Fly).
Photo © Signe Ellegaard.

WHAT IS NEEDED FOR THE FUTURE

To ensure that natural hydrology is protected or restored, three themes of work are proposed:

- Maintain or restore natural hydrological conditions, and restore or create small water bodies. Drainage in forests should be stopped or, in production forests, for instance, limited to a section of the area. Schemes for establishing water bodies in forests should be enhanced and promoted.
- Protect springs, flushes and water-saturated ground.
  Agricultural practices that contribute nutrient- or pollutant-rich water near springs, flushes and water-saturated ground should be altered towards reductions or permanently stopped.
- Protect wet meadows.
  There should be incentives and increased awareness to promote water-saturated soils and small water bodies in protected wet meadows, by reducing ditch maintenance. In addition, innovative strategies should be considered and applied to support land managers to maintain appropriate grazing regimes in wet meadows. For example, by fencing of larger areas that include both the wet meadow and neighbouring drier grassland.

GOAL 6: PESTICIDE USE IS RARE AND CAREFULLY TARGETED

THREATS AND CHALLENGES

Studies on pesticide residue levels in individuals of flower-visiting insects is currently only available for bees, and mostly honey bees. There is almost no information on the precise effects of pesticides on non-bee groups of flower-visiting insects (Uhl and Brühl, 2019). However, it is safe to assume that all insects, hoverflies included, are highly susceptible to the use of pesticides in their environment. Hoverflies may be affected through direct mortality when applied on or near their habitat. But pesticides may also affect hoverflies indirectly by causing trophic/ecosystem service changes and thus changing the habitat or the foraging resources which they rely on.

> *"The toxicity stays in the plant."*

The potential effects of pesticides on hoverflies include impaired reproduction, fewer egg-laying sites, altered foraging patterns or success, reduced prey availability for larvae with zoophagous feeding traits and increased disease and parasite susceptibility (Uhl and Brühl, 2019). Pesticides may also inadvertently move into adjacent wetlands or rivers, affecting aquatic larvae. More details on the dynamics of how pesticide use can affect hoverflies can be found in IUCN SSC HSG/CPSG (2022).

DRIFT OF HERBICIDES/PESTICIDES INTO NATURAL AREAS

Although intended to be applied to a certain aspect of the landscape, (e.g. crops), pesticides can disperse throughout the environment, ending up in unintended places, i.e. natural areas that are important hoverfly habitats.

The drift of pesticides into natural areas may change the habitat or the foraging resources which hoverflies rely on, causing indirect mortality. For instance, herbicides which are used to control weeds in agricultural fields, do not have a direct lethal effect on hoverflies, but may kill the flowering plants which hoverflies forage on. Similarly, pesticides may target aphids, which are important prey for zoophagous hoverfly species, thus removing an important feeding resource for hoverflies.

Drift of pesticides into non-target areas may be reduced significantly (>90%?) by using drift-reducing equipment when spraying the field. Use of such equipment is mandatory in Denmark, but it is important to control that farmers use the equipment correctly.

ENFORCEMENT OF PESTICIDE-FREE BUFFER ZONES AROUND PROTECTED NATURAL AREAS

It is important to avoid unintended dispersal of pesticides into non-target natural areas, for instance by enforcing pesticide-free buffer zones around protected areas. There is already legislation in place which prohibits the use of pesticides near protected natural areas. The width of the no-spray zone depends on the pesticide in question and may be reduced to 2 metres if the farmer uses drift-reducing equipment.

However, farmers or assistants doing the work in the field are not always aware of the presence of protected areas adjacent to their fields and may therefore spray too close. Certain apps allow the farmer to keep track of e.g. protected areas while working in the tractor, but farmers need to be trained to use them.

Excessive use of herbicides/pesticides

Use of pesticides and herbicides is a necessary tool in modern agriculture to keep unwanted pests under control. However, the application of pesticides simultaneously causes the direct mortality of many beneficial species living in the fields, including hoverflies.

An adult hoverfly can inadvertently consume pesticide residues that end up in the pollen and nectar of wildflowers within the field or the field margins. Likewise, hoverfly larvae can feed on aphids that have been feeding on treated crops, and thus be exposed to the pesticides the aphids were either sprayed with or ate themselves.

Therefore, the application of pesticides should be kept to an absolute minimum, and only when thresholds for specific pests are met.

Use of pesticides in private gardens and public spaces

Many private garden owners use pesticides as an easy and quick method to keep their garden tidy, and without necessarily being aware of the consequences of their actions for biodiversity. New legislation has made it illegal for private garden owners to buy pesticides in concentrated form, but it is still possible to buy pesticides in diluted form.

Veterinary medicines against ecto- and endoparasites

An often overlooked potential source of pesticides in the environment is medicating pets or livestock against fleas, ticks, mites, worms and other ecto- or endoparasites. Through flea collars and topical treatments, active ingredients can enter the (aquatic) environment directly (e.g. Perkins et al. 2021), and topic, oral or injection treatment can enter the environment indirectly through urine or faeces (e.g. Boxall 2003, 2004).

What is needed for the future

To ensure that pesticide use is rare and carefully targeted, two themes of work are proposed:

- Restrict the use of pesticides.
  Measures to enact the restricted use of pesticides should be enforced, supported and widely promoted.
- Reduce impacts from veterinary medication for ecto- and endoparasites.
  There should be greater awareness of this source of pesticide contamination among the public, farmers and graziers, and strategies identified and promoted to reduce the impact.

Goal 7: Any Commercial Beekeeping Practices in Denmark are Compatible with Hoverfly Conservation Efforts

Threats and challenges

In Denmark - and many other countries - there is a general concern whether commercial beekeeping in some areas could be a threat to wild pollinators, potentially resulting in reduced pollinator diversity, impaired pollination services and the spread of diseases to wild pollinators. Thus the challenges of ensuring sufficient pollination for agriculture become entangled with those of conserving the biodiversity of wild pollinators (e.g. Valido et al., 2019; Ropars et al., 2019, Ropars et al., 2020; and more details in IUCN SSC HSG/CPSG 2022). Especially wild species that depend on one or a few plants could be under pressure if honey bees also use the same plant species.

> *"Honey bees can no longer survive in Denmark without supplementary food - except for the native Apis melliferea mellifera (Brun bi, European dark bee)"*

Assessing the impact of honey bee competition on the population dynamics of wild bees and other pollinators can be highly challenging. In Denmark, Rasmussen et al. (2021) investigated the forage plant overlap between wild bees and managed honey bees. The study showed that among wild threatened bee species (CR, EN and VU on the Danish National Red List), 11 species showed more than 90% overlap of their forage plants with honey bees, and 30 species more than 70%. Among the latter, 6 species show a narrow, specialised preference for pollen sources. For these species it is important to be aware whether there is a period of the year where they might be competing with honey bees to their detriment. The same survey has not been carried out for hoverflies and butterflies, and we do not know to what extent there is a food overlap between honey bees and hoverflies. Furthermore, food overlap alone does not establish that there is competition for food sources, but it can guide

further studies and inform conservation planning, for instance by identifying species of potential concern. As Rasmussen et al. (2021) state: “Only with regular surveys and more data on the threatened species in Denmark can it be ascertained whether competition plays a role and how regulation of hive density in natural areas affect the populations of wild bees”.

Commercial honey bees are largely used for pollination of agricultural crops, such as rape and clover, as well as fruit and berries. But there are periods during the summer when there are no agricultural crops to pollinate, and when they are traditionally set out in forests and natural areas. In late summer, many beehives are also left on the heath to make heather honey. It is during the periods when the beehives are placed in nature that there is a need to know if there is a significant food overlap with threatened wild pollinators. Unfortunately, there is a lack of knowledge about where and when competition can arise, and therefore there is reason to exercise caution when placing beehives into the wild.

The Danish Nature Agency has chosen not to grant new permits for placing beehives in nature, and some private foundations have chosen not to have beehives in nature altogether. Commercial beekeeping will also not be allowed in nature national parks.

An alternative to placing beehives in natural areas is to establish flower strips on agricultural land, which can provide food for honey bees in the periods when there are no agricultural crops to pollinate. In this way, the wild pollinators are not exposed to competition in nature.

At Aarhus University DCE, researchers have started collaboration with researchers around the world, to see whether they can construct a risk assessment that will help identify whether there are safe thresholds for the number and density of beehives in nature.

WHAT IS NEEDED FOR THE FUTURE

To ensure that beekeeping in Denmark is compatible with hoverfly conservation efforts, two themes of work are proposed:

- Work from the best information about the impact of honey bees on hoverflies.
  There is a need to understand whether any hoverfly species overlap significantly with the food niche of honey bees, to identify potential species of concern for damaging competition.
- As a precautionary principle, consider avoiding placing honey bee hives, whether intended for honey production and/or pollination, in, or adjacent to, natural areas.
  There is a need to understand whether any hoverfly species overlaps significantly with the food niche of honey bees, to identify potential species of concern for damaging competition.
  In general, honey bees - like other farm animals - belong in the agricultural country. It should therefore be ensured that there is sufficient food for them throughout the year on agricultural land, for instance by establishing flower strips.
  If honey bees are placed in the wild, it should be ensured that there are no wild pollinators of concern that could be exposed to competition for important food sources. It should also be ensured that the individual apiaries are small and that there is a large distance between them.
  A good distance must be kept from vulnerable natural areas.

Goal 8: There are Sufficient Tools, Data, Databases and Experts For Effective Hoverfly Monitoring and Conservation in Denmark

> *"Besides butterflies, there is no tradition of monitoring insects in Denmark as it is done in other countries such as Germany and the UK."*

Challenges and opportunities

Effective monitoring and other scientific work on hoverflies are of critical importance to assess their up-to-date conservation status and trends, to provide a scientific foundation to guide future conservation work, and to evaluate the effect of implemented conservation actions. However, this currently presents a challenge to hoverfly conservation both at European level and in Denmark. IUCN SSC HSG/CPSG (2022) describes and explains the following challenges for hoverfly conservation in Europe, which generally also apply to Denmark: gaps in identification tools for hoverflies, commonly used monitoring methods not working well for hoverflies, too few hoverfly experts, poorly known life cycle requirements of (threatened) hoverflies, and difficulties faced by hoverfly experts in accessing resources for the work required.

Insects are a diverse and vital part of biodiversity in Denmark, and nature management and conservation would benefit from a more systematic approach to monitor this group. Monitoring programs for Natura 2000-areas include selected species, but guidelines are focused on plant communities. An array of species from the EU Habitats Directive's annexes are monitored, but these do not include hoverflies. However, in 20 state-owned 'untouched' forests, hoverflies are monitored systematically. The hoverfly monitoring is part of obtaining a wide baseline of biodiversity and ecological structures. The guidelines on how this is done could potentially be beneficial to circulate and use in more areas (https://ecos.au.dk/forskningraadgivning/temasider/baseline-monitering-af-statens-uroerte-skove - Niveau 3).

As hoverflies are a relatively small group, it would be beneficial if they could be part of a bigger monitoring scheme. A monitoring effort has been made in connection with *Atlasprojektet Danmarks Svirrefluer (Atlas project of Danish Hoverflies)* I, II and III.

> *"It is a problem that we don't have all the relevant data in one place."*

Presently, hoverfly data is scattered and not all available in one place. There are only few records in the Global Biodiversity Information Facility (GBIF) and distribution data is generally lacking from the national and global red list databases, where some occurrence data are missing. A challenge that might be solved by increasing funding for a more detailed red list.

Overall, a systematic approach for both monitoring hoverflies and utilising hoverfly data would be beneficial for hoverfly conservation in Denmark. Additionally, more Danish experts are needed, and existing experts need to be included in more research, counselling and in the IUCN SSC Hoverfly Specialist Group. Zoological experts have become less numerous in Denmark, but this course of direction is changing, and groups such as *De Unge Biodiversitetsambassadører (The Young Biodiversity Ambassadors)* could be a source of inspiration for more young people.

The preliminary multi-species plan "European Hoverflies: Moving from Assessment to Conservation Planning" lists the following projects supported by the European Commission / EU Pollinator Initiative. They present potential current and future opportunities for resources and/or a support framework to help tackle the challenges in this area in Denmark, and allow Denmark to contribute to the European knowledge and resource base (extracted from IUCN SSC HSG/CPSG (2022)).

BOX 3 Projects supported by the European Commission/EU Pollinator Initiative

The **EU Pollinator Monitoring Scheme (EU POMS)** (including hoverflies) is a key action proposed in the **EU Pollinators Initiative (EPI)**. The scheme lays out a.o. standard monitoring protocols, requirements, and estimated costs, as well as proposals for specialised monitoring of threatened species, with indicators to enable evaluation of actions taken to tackle declines.

SPRING (Strengthening Pollinator Recovery through INdicators and monitorinG): aims to support preparation for implementation of the EU Pollinator Monitoring Scheme EU POMS) by organising training to build capacity and through a pilot scheme which will involve monitoring at a small number of sites in every EU Member State. https://www.ufz.de/spring-pollination/

TAXO-FLY (Taxonomic Resources for European Hoverflies) (under direction of the University of Helsinki's Finnish Museum of Natural History, Luomus)**:** is collecting taxonomic, morphological, and ecological data for all European hoverfly species, and will establish an open access EU Commission hosted website for this information. (https://www.helsinki.fi/en/news/biodiversity-loss/european-hoverfly-species-information-be-gathered-eu-funded-project/)

SAFEGUARD (safeguarding European wild pollinators): A research project under Horizon 2020 Europe that aims, among other things, to improve knowledge of EU-wide pollinator distribution (https://www.safeguard.biozentrum.uni-wuerzburg.de/).

STING (Science and Technology for pollinating Insects): a project preparing training resources for hoverfly identification and testing of planned EU pollinator monitoring. (https://knowledge4policy.ec.europa.eu/projects-activities/sting-project_en).

DEST (Distributed European School of Taxonomy) was established by prominent taxonomists and other international partners during the EU funded project European Distributed Institute of Taxonomy (EDIT: 2006 – 2011). One of these is dedicated specifically to the Syrphidae (though the latest version focused more generally on pollinators. DEST activities are under the umbrella of CETAF (Consortium of European Taxonomic Facilities): https://cetaf.org/dest/courses/ New researchers will be trained to take part in EU POMS and each EU country will establish national centres for monitoring pollinators.

Red List of Taxonomists: Also EU supported. Aims to: detail information on the current number, location and profile of insect taxonomists; assess the status and future trends of insect taxonomic expertise in Europe; and to improve the understanding among policy makers, stakeholders and the general public, of the role of a solid European taxonomic community to reverse insect decline.

WHAT IS NEEDED FOR THE FUTURE

To ensure that hoverflies can be effectively monitored and conserved in Denmark, four themes of work are proposed:

- Consolidate all validated hoverfly data in a central, public database (present and historical).
  It is important for the future to have a single, comprehensive, up-to-date and readily accessible information resource for hoverfly records, to support their monitoring and conservation in Denmark. It is recommended that this resource is arter.dk
- Establish a national monitoring programme that includes hoverflies and other taxa.
  Systematic, standardised monitoring of hoverflies should be established through a national monitoring programme. This will enable patterns in hoverfly (as well as other species) abundance and diversity to be tracked over time. Among other things, this will help identify where conservation is needed and whether it is working.
- In the future, there should be more Danish non-vocational hoverfly experts contributing to national, regional and global hoverfly projects. There are now opportunities for engagement through several European initiatives.
- Increase threat and habitat details in the Danish Red List.
  Funding support should be increased for the Danish Red List, to enable more comprehensive coverage of species occurrence, microhabitats, threats and conservation needs and to attract more experts to support the work required.

Frits Ahlefeldt

Goal 9: Relevant Sectors of Society Know what Hoverflies are and are Aware of Their Ecological Value, Conservation Needs, and What They Can Do to Help Conserve Them

Challenges

Despite an increase in communication and awareness raising about wild pollinators and their conservation needs, hoverflies have received comparatively little attention. Many people might mistake hoverflies for stinging insects like bees or wasps, or flies in general, and in many traditional Danish gardens the biodiversity is so low that you will only see the most common species like *Episyrphus balteatus* (Dobbeltbåndet svirreflue) and *Merodon equestris* (Stor narcisflue). That is despite the fact that many species of hoverflies are easy to observe and have a striking appearance. Most people are also unaware of the importance of hoverflies as a pollinator group.

Becoming aware of the presence and diversity of hoverflies often follows awareness of other species like butterflies and bumblebees. When people make more butterfly- or bee-friendly gardens, the number of hoverflies rises too — even more so if a few changes are made to cater for the needs of their larvae.

Topics and Messages

Message topic areas

Hoverflies thrive in diverse flower rich habitats with a lot of ecotones, natural hydrology, dead/dying or damaged/veteranised wood/trees, and grazing. Therefore, hoverflies are excellent indicators for the quality of habitats and ecosystems.

Detailed messaging

Natural pest control

Like other insects, hoverflies are very susceptible to pesticides; but hoverflies are harmless and often beneficial. They are an excellent alternative to pesticides because hoverfly larvae of many zoophagous species eat aphids.

Pollination by the unknown

In Europe, hoverflies are the most important pollinator group together with native bees, but they are often overlooked, though they are a very species-rich group of insects with a number of very common species.

A wet untidy forest is high-quality nature

An untidy forest is a great forest. The dead tree parts and wounds are not just a half-dead tree but an important habitat and source of life. It is important to preserve the old trees and dead wood to preserve the habitats and the biodiversity connected to those. If it is necessary for safety reasons, it is better to take the branch instead of the whole tree. The trees are not just a habitat, they also provide shelter to the areas around them.

Old trees and veteran trees are key habitats for hoverfly larvae (and other invertebrates), but poorly protected. There is also a dire need to map and register the veteran trees as key habitats for hoverflies and other species.

Water bodies are a natural part of our ecosystems

Natural hydrology is important for biodiversity in all ecosystems and especially for the hoverfly species whose larvae are tightly associated with different water bodies in forests and in more open areas.

Denmark is flat and coastal and so naturally wet, with wet soils, temporary water ponds, lakes, and stream valleys. Many water bodies in farmland and forests have been removed and a lot of habitats have disappeared with them.

Habitat development and specialisation takes time

Good (micro)habitats take a long time to develop, and it takes time for them to become inhabited with a rich diversity of fauna, flora and fungi. Many species including hoverflies are often specialised to a very particular type of biotope within the habitat. Therefore, habitats cannot easily be replaced without species loss.

The quality of many habitats is determined by the degree and the quantity of natural processes including appropriate grazing.

The value of a species

Just as we highlight butterflies, there are beautiful hoverflies, which should be highlighted. There are twice as many hoverflies as birds, and they are often rare and threatened just like birds and orchids. Paying attention to hoverflies will give you great experiences and will enrich your life.

People and hoverflies

Pollination campaigns are effective and could easily include hoverflies. Together with small pocket identification keys it could raise awareness about hoverflies, not just among landowners but also garden owners. It could inspire people to see their gardens as an important food source for species, including hoverflies. An untidy garden (with leaf and herb litter, humidity, small water puddles, native herbs and flowering shrubs/trees etc.) is a great garden, full of microhabitats and food sources! It may also nudge people not to use pesticides.

Stakeholder Groups to Engage in Awareness Raising

Stakeholder groups that should be the subject of awareness raising with the messages outlined above include, but are not limited to:

- children
- visitors
- landowners
- garden Owners
- forest Owners
- politicians
- municipalities
- students
- authorities

BOX 4 Example of an awareness-raising activities

In collaboration with artist Frits Ahlefeldt, a poster was created visualizing the project. The poster is available in both English and Danish.

Options for awareness-raising activities

The following is a non-exhaustive list of ideas for concrete awareness-raising activities:

- Publish a poster of beautiful hoverflies in Denmark like the ones made for butterflies, birds, orchids, etc.
- Publish a pixie-book with hoverflies so land/garden-owners can tick off what hoverfly and hoverfly habitats they have in their garden/farm/forest.
- Organise excursions with experienced hoverfly guides so interested people can get a chance to learn about hoverflies.
- Inspire more biology students to research hoverflies e.g. in biology classes with a focus on pollination.
- Promote the current trend of Vild Med Vilje (Wilfully Wild) and revise the communication and information materials to include larval feeding traits and larval habitats of different insect groups.
- Promote hoverflies in state forests along the same lines as birds, plants, butterflies, reptiles and amphibians (e.g. highlight some species at the entrance/points of departure for walking routes etc.).
- Make a hoverfly bingo for children which can be used in primary schools, kindergartens etc.
- Revise teaching materials and documentaries to include hoverflies.
- Ensure a broader focus on biodiversity and include more groups of species.

Existing initiatives

Already existing awareness raising initiatives include, but are not limited to the following:

- SEGES Innovation has initiated a pollinator campaign consisting of 10 insect-friendly actions for farmers. Each action is described and its effect on wild pollinators is scored.
- DUB Denmark (The Young Biodiversity Ambassadors) makes initiatives to bring nature and biodiversity back into people's lives and raises awareness about biodiversity. DUB Denmark does not work specifically with hoverflies and pollinators in general, but aspects of this could be incorporated in their work.
- Naturbasen and National History Museum Aarhus cooperates on the Citizen Science Project 'Svirreflueatlas III' (hoverfly atlas) Atlasprojektet Danmarks Svirrefluer 2.0 (svirreflueatlas.dk)
- Vild Med Vilje (Wilfully Wild) has a primary goal to bring wilderness and nature back where people live, work and play. They do not specifically work with hoverflies and pollinators in general but through inspiration and sharing of knowledge they inspire people to create habitats suitable for a wide range of species in private gardens, areas, and public spaces. Aspects important to hoverflies could be incorporated.
- The Ministry of Environment has initiated a competition to become the Wildest Municipality in Denmark (https://dkvild.dk). The municipalities are encouraged to involve citizens, businesses, and local institutions such as primary and lower secondary schools, nursing homes and others. The competition ended ultimo 2022. The competition does not work specifically with hoverflies or wild pollinators, but it raises awareness about biodiversity and many of the

projects create new habitats suitable for a wide range of species. Any future editions (or similar initiatives) could incorporate aspects important to hoverflies.

- There are two Danish podcasts 'Vildspor' and 'Vildt Naturligt' that focus on nature and biodiversity. They do not cover hoverflies specifically, but they raise awareness about species, biodiversity and natural processes in the ecosystems including dead wood, hydrology, coastal dynamic, megafauna etc. which will benefit many species of hoverflies.

WHAT IS NEEDED FOR THE FUTURE

To ensure greater awareness of hoverflies and increased participation in their conservation, the following area of work was proposed:

- Implement awareness-raising initiatives focused on the messages and target audiences mentioned in this report.
  Through a series of innovative education and advocacy initiatives, general awareness of hoverflies should be increased among key audiences, leading to increased perception of their value and benefits, and greater interest and commitment to their conservation.

Frits Ahlefeldt

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APPENDIX 1: TABLE OF GOALS, OBJECTIVES AND ACTIONS

Table 1: **Objectives and recommended actions identified by the collaborators for each goal for hoverfly conservation in Denmark.** Due to the pilot project nature of this planning initiative, recommendations generated should be considered the best advice from the stakeholder group involved, rather than the official viewpoint or plan of action from Miljøstyrelsen. A formal action plan would have included the identification of stakeholder groups and organisations to take actions forward and would have invested additional time and consultation to ensure that the package of actions is complete. Nevertheless, these recommendations can guide and help promote positive action for hoverflies across a wide range of societal sectors. Recom = Recommended action. Tick marks indicate to which of the following areas the recommended actions contribute: MH - microhabitat preservation/restoration; N&P - mitigating effects of excess nutrients and pesticides; HB – preventing potential competition from commercial beekeeping practices; P&I – supporting/adjusting policies and incentives; A – raising awareness about hoverflies and their needs; D,T&E – addressing gaps in data, tools and experts.

	Description	MH	N&P	CBK	P&I	A	D,T&E
GOAL 1	**Old and veteran trees, and their features, are valued and protected.**						
Objective 1.1	**Promote veteran trees as habitats.**						
Recom 1.1.1	Assign veteran trees the status of "habitat" in policies.	x			x		
Recom 1.1.2	Raise awareness of the value of veteran tree habitats among landowners, foresters & citizens with gardens.	x				x	
Objective 1.2	**Increase protection of (individual) veteran trees.**						
Recom 1.2.1	Whenever possible, rather than removing standing veteran trees from public areas for public safety, move walking paths instead, or restrict/redirect public access at risky times (e.g. during a storm).	x				x	
Recom 1.2.2	Increase the value and decrease the bureaucracy of the current subsidy scheme for protecting single-standing trees (administered by the Department of Agriculture), to make the protection of such trees more rewarding.	x			x		
Recom 1.2.3	Encourage farmers to report on protecting old and veteran trees in Environmental, Social and Governance (ESG) reports.	x			x	x	
Recom 1.2.4	Encourage companies to report on their contributions to protecting old and veteran trees via the "EU Taxonomy" initiative.	x			x	x	

	Description	MH	N&P	CBK	P&I	A	D,T&E
	https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en						
Recom 1.2.5	Include in the FSC certification scheme, some appropriate, area-specific targets (in cubic metres) of dead and dying wood per hectare. Establish, for instance, different targets for protected areas and “unmanaged forest".	x			x		
Recom 1.2.6	Connect areas with veteran trees with corridors comprising good-quality habitat.	x					
Recom 1.2.7	Ensure legal protection of (veteran) trees and vegetation on old fences, earth banks, hedgerows and in connection with tree-lined avenues, especially next to existing natural habitat.	x			x		
Objective 1.3	**The next generation of veteran trees is protected at biodiversity hotspots.**						
Recom 1.3.1	Identify biodiversity hotspots with large numbers of saproxylic invertebrates, including hoverflies, and ensure there is a continuity of veteran tree features in especially these areas, e.g. through some of the subsequent recommended actions.	x					x
Recom 1.3.2	Increase subsidies for planting new forest where it is most needed, i.e. at hotspots.	x			x		
Recom 1.3.3	Plant more trees that are good at developing veteran features quickly, e.g., elm, alder, willow, aspen, birch, pine. Several are shorter-lived trees, but they can fill microhabitat gaps in the shorter term.	x					
Recom 1.3.4	Damage trees to speed veteranisation and to support hoverfly populations until the new generation of trees grows old.	x					

	Description	MH	N&P	CBK	P&I	A	D,T&E
Recom 1.3.5	Provide subsidies to landowners for veteranising trees, allowing them to choose which of their trees are veteranised.	x			x		
Recom 1.3.6	When planting trees to create corridors between old forests, identify and protect bulb hotspots and the herb layer, thus protecting larval microhabitats and food sources for adult hoverflies.	x					
Recom 1.3.7	Provide guidance on areas where forest managers should not cut trees, e.g. key biotopes and important elements of the forest.	x				x	
GOAL 2	**Forest management supports hoverflies.**						
Objective 2.1	**Ensure adequate larval habitat in forests and ecotones.**						
Recom 2.1.1	Include a higher diversity of trees in productive stands in terms of species composition and age.	x				x	
Recom 2.1.2	Support the proposal as part of the Renewable Energy Directive that states that biomass for energy cannot be harvested from old growth forest and that wood harvested from primary forest will not count as renewable energy. This proposal has not been adopted yet.	x			x		
Recom 2.1.3	Promote appropriate levels of grazing in forests (see also Goal 3) to create light open areas and ecotones (to increase microhabitats and food sources for hoverfly larvae and adults), help disperse seeds and help veteranise trees.	x			x	x	
Recom 2.1.4	Restore/maintain natural hydrology in forests (see also Goal 5), reduce or stop drainage and maintain small water bodies & water-saturated ground.	x			x		
Objective 2.2	**Ensure adequate adult habitat in forests.**						
Recom 2.2.1	'Seed' forests with good pollen sources for adults, e.g. a mix of elderflower, crab apple, blackthorn, hawthorn, rowan, willow – providing a good spread of pollen across the season.	x					

	Description	MH	N&P	CBK	P&I	A	D,T&E
Recom 2.2.2	Stop weeding (or do as little as possible in commercial forests) to allow more diversity of pollen-bearing plants.	x					
Recom 2.2.3	Actively plant for a diverse herb layer when converting production forest to nature.	x					
Objective 2.3	**Ensure awareness of the benefits of managing forests for hoverflies.**						
Recom 2.3.1	Increase awareness among landowners on managing forests for attracting insects, including hoverflies, to benefit from the services that they provide, e.g. pest control.	x				x	
GOAL 3	**There is a diverse herb layer in open areas as well as forests — and ecotones between them.**						
Objective 3.1	**Stimulate grazing over mowing.**						
Recom 3.1.1	Develop a national subsidy scheme that favours grazing over mowing.	x			x		
Recom 3.1.2	Review current schemes with a focus on making it easier to graze with mixed species and for different owners of cattle to graze their cattle in the same area.	x			x		
Objective 3.2	**Optimise the benefits to farmers of current biodiversity-directed grazing subsidies.**						
Recom 3.2.1	Reconsider the recommended grazing level of semi-natural areas where biodiversity conservation is prioritised above production.	x			x		
Objective 3.3	**Change public perceptions about (appropriate) grazing in natural landscapes.**						

	Description	MH	N&P	CBK	P&I	A	D,T&E
Recom 3.3.1	Increase public awareness and influence perceptions about: a) grazing being a natural process b) grazing animals being a natural part of the landscape.	x				x	
Objective 3.4	**Support the presence and continued existence of ecotones.**						
Recom 3.4.1	Allow and/or facilitate extensive grazing, natural fire regimes, natural hydrology, natural coastal dynamics and wind felling through storms, bark beetles, strong winds, as these events support the presence and continuity of ecotones.	x			x		
Recom 3.4.2	Improve perceptions of the value of the events and processes described in recommended action 3.4.1 for the preservation of gradual ecotones.					x	
Recom 3.4.5	Achieve/restore habitat connectivity where possible to allow hoverfly species to repopulate areas from which they have disappeared. Additionally use translocation of hoverflies and/or critical microhabitats/substrates/resources, in areas where connectivity to facilitate natural movement is not possible.	x					
GOAL 4	**Dune systems are dynamic and biodiverse.**						
Objective 4.1	**Enable year-round grazing in dune systems.**						
Recom 4.1.1	Make it possible to get dispensation for providing shelters for the grazing livestock, or ensure access to a small, wooded area that will provide natural shelter, e.g. an adjacent forest.	x			x		
Objective 4.2	**Ensure continuity of habitats for pine-dependent species.**						
Recom 4.2.2	If mountain pine plantations are converted to plantations with non-invasive, native pine species, ensure that the conversion is sufficiently gradual to provide continuous, sufficient microhabitat for hoverfly populations relying on pine.	x			x		

	Description	MH	N&P	CBK	P&I	A	D,T&E
GOAL 5	**Natural hydrology is protected or restored — especially small water bodies and water-saturated ground.**						
Objective 5.1	**Maintain or restore natural hydrology and restore or create small water bodies.**						
Recom 5.1.1	Make schemes for establishing water bodies in forests more attractive to potential users and promote them.	x			x	x	
Recom 5.1.2	Reduce or remove drainage in forests to create permanently wet ground and consequently generate the required levels of humidity for hoverflies and encourage a healthy herb layer. In production forests, do this for a section of the area.	x			x		
Objective 5.2	**Protect springs, flushes and water-saturated ground.**						
Recom 5. 2.1	On land surrounding springs and other important water sources, incentivise permanent cessation or alteration of agricultural practices.	x	x		x		
Objective 5.3	**Protect wet meadows.**						
Recom 5.3.1	Install a flexible, easy to control scheme that incentivises stopping cleaning wet meadow drainage ditches.	x			x	x	
Recom 5.3.2	Raise awareness among nature managers that no longer cleaning wet meadow drainage ditches can be beneficial for biodiversity, including hoverflies.	x				x	
Recom 5.3.3	In order to support land managers with maintaining appropriate grazing regimes in wet meadows, promote the fencing of larger areas that include both the wet meadow and the neighbouring drier grassland to reduce the intensity of grazing over short periods of time. Grazers can move between the two zones, and thus the conditions for receiving subsidy are met.	x				x	

	Description	MH	N&P	CBK	P&I	A	D,T&E
GOAL 6:	**Pesticide use is rare and carefully targeted.**						
Objective 6.1	**Restrict the use of pesticides.**						
Recom 6.1.1	Enforce support, and widely promote existing measures that restrict the use of pesticides.		x		x	x	
Objective 6.2	**Reduce impacts from veterinary medication against ecto- and endoparasites.**						
Recom 6.2.1	Raise awareness of this as an issue among the public (e.g. pet owners) and farmers, graziers etc.		x			x	
Recom 6.2.2	Promote the practice of keeping grazing animals back for 8 weeks post-medication, before putting them out to graze in/near sensitive areas.		x			x	
GOAL 7	**Any commercial beekeeping practices in Denmark are compatible with hoverfly conservation efforts.**						
Objective 7.1	**Work from the best information about the impact of honeybees on hoverflies.**						
Recom 7.1.1	Conduct a study equivalent to that of Rasmussen et al. (2021), but on hoverflies, to understand whether any (threatened) hoverfly species overlap significantly with the food niche of honey bees. This would allow identification of potential hoverfly species of concern for damaging direct competition.			x			x
Recom 7.1.2	As a precautionary principle, consider avoiding placing beehives, whether intended for honey production and/or pollination, in, or adjacent to, natural areas.			x		x	
Recom 7.1.3	Promote a principle that farmers are to plant flower strips on their agricultural land that can provide food for honeybees in the periods when there are no agricultural crops to pollinate (thus avoiding			x		x	

	Description	MH	N&P	CBK	P&I	A	D,T&E
	needing to place them in nature to bridge those periods). Honeybees should in that sense be considered part of the farm's livestock.						
GOAL 8	**There are sufficient tools, data, databases and experts for effective hoverfly monitoring and conservation in Denmark.**						
Objective 8.1	**Consolidate all validated hoverfly data in a central, public database (present and historical).**						
Recom 8.1.1	Make sure all historical data is logged via arter.dk				x		x
Recom 8.1.2	Ensure public monitoring via arter.dk				x		x
Objective 8.2	**Increase threat and habitat details in the Danish Red List.**						
Recom 8.2.1	Increase funding for the Danish Red List to enable more comprehensive coverage of species occurrence, (micro)habitats, threats and conservation needs and to attract more experts to support the work required.				x	x	x
Recom 8.2.2	Analyse existing hoverfly data (from multiple sources) to inform in Red List assessments, planning and action for hoverflies.						x
Objective 8.3	**Have more Danish non-vocational hoverfly experts contributing to national, regional and global hoverfly projects.**						
Recom 8.3.1	Encourage professional and non-vocational Danish hoverfly experts to participate in national, regional and global hoverfly projects.						x
Objective 8.4	**Establish a national monitoring programme to include hoverflies and other taxa.**						
Recom 8.4.1	Provide funding for volunteers to run Malaise trapping projects.				x		x

	Description	MH	N&P	CBK	P&I	A	D,T&E
Recom 8.4.2	Participate in the intended EU POMS (EU Pollinator Monitoring Scheme) training project under the EU Pollinator Initiative. Denmark is listed as one of the country locations.				x		x
Recom 8.4.3	Ensure that Denmark is represented in the EU work recommended for hoverflies under the EU Pollinator initiative documents.				x		x
Recom 8.4.4	Ensure that at least one Danish expert is included in the IUCN SSC Hoverfly Specialist Group.						x
GOAL 9	**Relevant sectors of society know what hoverflies are and are aware of their ecological value, conservation needs, and what they can do to help conserve them.**						
Objective 9.1	**Implement awareness-raising activities/initiatives focused on the topics/messages and target audiences mentioned in this report. They can include but are not limited to those below.**						
Recom 9.1.1	Make a small pocket identification key for hoverflies.					x	
Recom 9.1.2	Make a poster of the many beautiful hoverflies in Denmark like the ones made for butterflies, birds, orchids etc.					x	
Recom 9.1.3	Publish a hoverfly pixie-book/flyer – so land/garden-owners can tick off what hoverfly and hoverfly habitats they have in their garden/farm/forest.					x	
Recom 9.1.4	Make a hoverfly nature calendar with pictures of hoverflies and habitats.					x	
Recom 9.1.5	Organise excursions with experienced hoverfly guides so interested people can get a chance to learn about hoverflies.					x	

	Description	MH	N&P	CBK	P&I	A	D,T&E
Recom 9.1.6	Incorporate hoverfly aspects into the current trend of 'Vild Med Vilje' (Wilfully Wild).	x				x	
Recom 9.1.7	Create a hoverfly bingo for kids.					x	
Recom 9.1.8	Create a 'Top Trumps' card game with hoverflies.					x	
Recom 9.1.9	Integrate hoverflies into teaching materials and documentaries.					x	x
Recom 9.1.10	Get more biology students onto the task of investigating hoverflies.					x	x
Recom 9.1.11	Integrate hoverfly aspects into national campaigns, such as the ones SEGES has been conducting.					x	
Recom 9.1.12	Promote awareness of the presence of hoverflies in state forests, as is being done with birds, plants, butterflies, reptiles and amphibians.					x	

APPENDIX 2: LIST OF THREATENED HOVERFLIES IN DENMARK

Bygebjerg, R., 2019. *Svirrefluer*. I Moeslund, J.E. m.fl. (red.): Den danske Rødliste 2019. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, redlist.au.dk.

Scientific name	Danish name	Red List category
Anasimyia lunulata	Sen damsvirreflue	EN
Arctophila bombiformis	Gul bjørnesvirreflue	EN
Arctophila superbiens	Brun bjørnesvirreflue	EN
Brachyopa bicolor	Tofarvet træsaftsvirreflue	EN
Brachyopa panzeri	Panzers træsaftsvirreflue	EN
Brachyopa scutellaris	Nyre-træsaftsvirreflue	EN
Caliprobola speciosa	Pragtsvirreflue	EN
Chalcosyrphus valgus	Sort træsmuldsvirreflue	VU
Cheilosia antiqua	Kodriver-urtesvirreflue	VU
Cheilosia flavipes	Gulbenet urtesvirreflue	VU
Cheilosia frontalis	Sump-urtesvirreflue	EN
Cheilosia nebulosa		VU
Cheilosia vulpina	Artiskok-urtesvirreflue	VU
Chrysotoxum verralli	Verralls hvepsesvirreflue	CR
Criorhina floccosa	Uldhåret pelssvirreflue	EN
Doros profuges	Hvepsetalje-svirreflue	CR
Eristalis cryptarum	Hedemose-dyndflue	EN
Eristalis oestracea	Bremse-dyndflue	CR
Eristalis rupium	Kilde-dyndflue	EN
Eumerus ornatus	Smuk løgsvirreflue	VU
Eumerus sogdianus	Asiatisk løgsvirreflue	VU
Heringia heringi	Mørk løvgallesvirreflue	VU
Lejogaster tarsata	Broget metalsvirreflue	VU
Lejops vittata	Kogleaks-damsvirreflue	VU
Mallota cimbiciformis	Uld-svirreflue	CR
Merodon avidus	Smal narcisflue	VU
Myolepta dubia	Gul træhulflue	EN
Neoascia annexa	Bredbåndet køllesvirreflue	VU
Neoascia geniculata	Korthornet køllesvirreflue	EN
Neoascia interrupta	Plettet køllesvirreflue	VU
Neocnemodon brevidens		VU
Neocnemodon verrucula	Vortet sporesvirreflue	VU
Orthonevra elegans	Smuk mosesvirreflue	CR
Paragus albifrons	Strandeng-maskesvirreflue	EN
Paragus finitimus	Klithede-maskesvirreflue	EN
Paragus tibialis	Klit-maskesvirreflue	EN
Pelecocera lusitanica	Dværg-svirreflue	EN
Platycheirus immarginatus	Kyst-bredfodsflue	EN
Platycheirus podagratus	Lang bredfodsflue	VU

Platycheirus tarsalis	Tidlig bredfodsflue	EN
Platycheirus transfugus	Gulplettet spiralhårsflue	VU
Pocota personata	Jordhumle-svirreflue	EN
Psilota atra		VU
Sphaerophoria loewi	Tagrør-kuglebærerflue	EN
Sphaerophoria potentillae	Tormentil-kuglebærerflue	VU
Sphegina verecunda	Mørk barksvirreflue	VU
Syrphus nitidifrons		VU
Temnostoma apiforme	Bredbåndet vedsvirreflue	EN
Temnostoma meridionale		EN
Trichopsomyia joratensis	Sort hårsvirreflue	VU
Volucella inanis	Gul humlesvirreflue	VU
Xanthogramma citrofasciatum	Tidlig ornamentsvirreflue	EN
Xylota abiens	Lille træsvirreflue	VU
Xylota meigeniana	Skinnende træsvirreflue	VU
Xylota xanthocnema	Gulbenet træsvirreflue	VU

APPENDIX 3: LIST OF CONTRIBUTORS

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