UK Biodiversity Indicators 2023

This documents supports
D1c. Status of pollinating Insects

Technical background document:

The Biological Records Centre

For further information on D1c. Status of pollinating insects visit http://www.jncc.gov.uk/ukbi-D1c

For further information on the UK Biodiversity Indicators visit http://www.jncc.gov.uk/ukbi

D1c - Biodiversity and Ecosystem Services – status of pollinating insects – technical background document

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Introduction

Pollination is a vital ecosystem service that benefits agricultural and horticultural production, and is essential for maintaining wild flower biodiversity. By improving the yield, quality and resilience of crops, insect pollination has been valued at £400 million per year to the UK economy (POST, 2010). 35% of the world's agricultural output, by volume, consists of 87 crop types that benefit from pollination by animals (insects, birds and mammals), but because most of these crops are not entirely dependent on animal pollination, the amount of production directly attributable to animals is lower than this value (Klein *et al.*, 2007). There is growing concern regarding the population status of insect pollinators, and in turn the pollination service they provide (Potts *et al.*, 2010; Garratt *et al.*, 2014). As with most other areas of biodiversity, the main threats to pollinators include habitat loss, environmental pollution, climate change and the spread of alien species (Klein *et al.*, 2007; Potts *et al.*, 2010; Vanbergen & The Insect Pollinators Initiative 2013). The widespread application of pesticides is also perceived as a major threat to pollinator diversity (Brittain *et al.*, 2010). In order for governments to act upon these threats they need robust metrics on the national-scale status of pollinators and pollination, though deriving such a metric has previously been limited by the availability of suitable data and analytical techniques and the species considered to be wild pollinators are subject to debate (Hutchinson *et al*. 2021). With the increase in citizen science, the availability of large-scale biological record data has increased (Silvertown, 2009). Such data are collected without a standardized survey protocol and therefore extracting reliable trends from them can be difficult. However, with recent analytical advances it is now possible to estimate reliable trends from such data (van Strien *et al.*, 2013; Isaac *et al.*, 2014).

Methods

Data sources

Occurrence records of bee and hoverfly species within 1km grid cells in the UK originate from the Bees, Wasps and Ants Recording Society (BWARS) and the Hoverfly Recording Scheme biological records databases. The time-period used for the indicator was 1980 to 2022, as this represents a core period of recording for these taxa in the UK. Bee species were filtered (following expert guidance from BWARS) so that only species considered to be wild pollinators were included. Species that had undergone taxonomic changes or had taxonomic issues during the time frame of the indicator were excluded from the analysis. The final composite indicator was based on 394 species of wild pollinator, see Appendix 1 for a list of species covered. Note that the species considered to be wild pollinators are subject to review, following feedback from the scientific community and the publication of a literature review of field survey data recording wild bee visits to crops in Great Britain and Europe (Hutchinson et al. 2021).

Generating species' trends and the composite indicator

The data used to produce the indicator were not collected using a standardised protocol, but instead are a collation of unstructured biological observations collected by a large network of volunteer recorders. Such data tend to contain many forms of sampling bias and noise, making it hard to detect genuine signals of change (Tingley & Beissinger, 2009; Hassall & Thompson, 2010; Isaac et al., 2014). Recent studies have highlighted the value of Bayesian occupancy models for estimating species occurrence in the presence of imperfect detection (van Strien et al., 2013; Isaac et al., 2014). This approach uses two hierarchically coupled sub-models: an occupancy sub-model (i.e. presence verses absence), and a detection sub-model (i.e. detection verses non-detection).

Together these sub-models estimate the conditional probability that a species is detected when present. Species-specific time series estimates are derived from a Bayesian occupancy model, described in Outhwaite et al. (2019) and following van Strien et al. (2013) and Isaac et al. (2014), with improvements based on Outhwaite et al. (2018). Annual estimates of occupancy, with estimates of uncertainty, are available for 5,293 UK invertebrate, bryophyte and lichen species for the period 1970 to 2015 (Outhwaite et al. 2019). These models are updated as and when new data become available from recording schemes. For each site-year combination the model estimates presence or absence for the species in question given variation in detection probability: from this the proportion of occupied sites ('occupancy') was estimated for each year. To estimate the composite indicator trend with uncertainty, the posterior distribution of the annual occupancy estimates for each species was utilised.

A change from the approach used to select species-specific trends for the 2021 indicator is the adoption of new criteria, based on the suitability of the underlying data for producing occupancy trends with acceptable precision. As in the 2022 publication, we used a data-driven approach to define criteria (rules-of-thumb) to select species-specific trends to include in the indicator. The rules-of-thumb are based on the suitability of the underlying data for producing occupancy trends with acceptable precision and are considered to be more objective than the previous threshold of 50 records (Pocock *et al.* 2019) used before 2022. Rarely recorded species (< 1 record in every 100 visits) were excluded if there were fewer than 3.1 records across the 10% of the best recorded years. More frequently recorded species were excluded if there were fewer than 6.7 records across the 10% of the best recorded years (Pocock *et al.* 2019). Exclusion criteria are based on classification trees, selected to balance the rates at which species are excluded when not meeting precision thresholds and included when meeting the precision thresholds. In total, the 2023 indicator comprises 394 species that met these criteria for inclusion. This represents a net increase of 5 species compared with the 2022 indicator.

The composite indicator was produced using a novel hierarchical modelling method for calculating multi-species indicators developed by UKCEH (Freeman et al. 2020), which offers some advantages over the geometric mean method used to produce the indicator prior to 2022. It can be applied to multiple data types, improving the comparability between metrics derived from occupancy and abundance data and can account for the uncertainty associated with the underlying species-specific time series as well as uncertainty in the indicator arising from the subset of species that are included. Case studies with four taxonomic groups show it to be robust to missing values, especially when these are non-random, for example when declining species are more likely to be missing observations in recent years or if recent colonists are absent earlier in the time series. Imputing missing values is informed by between-year changes in species for which data is available, assuming shared environmental responses. Additionally, a smoothing process is used to reduce the impact of between-year fluctuations - such as those caused by variation in weather - making underlying trends easier to detect. The smoothing parameter (number of knots) was set to the number of years divided by three following Fewster et al. (2000).

The indicator represents annual change in the geometric mean estimated occupancy across the constituent species. The index is set to a value of 100 in the start year (the baseline), so that changes subsequent to this represent proportional change in occupancy; if on average species' trends doubled, the indicator would rise to 200, if they halved it would fall to a value of 50.

Species-specific trends

For each species, the long- and short-term trend in occupancy was estimated as the mean annual percent change (over the time-period in question) across 1,000 estimates from the posterior distribution. Species were grouped into one of 5 categories based on both their short-term and long-term occupancy trend (Table 1). The threshold values for each category were based on those of the wild bird indicator; whether an individual species is increasing or decreasing has been decided by its rate of annual change over the time period (long or short) of interest. If the rate of annual change would lead to an occupancy increase or decrease of between 25% and 49% over 25 years, the species is said to have shown a 'weak increase' or a 'weak decline' respectively. If the rate of annual change would lead to a population increase or decrease of 50% or more over 25

years, the species is said to have shown a 'strong increase' or a 'strong decline' respectively. These thresholds are used in the Birds of Conservation Concern status assessment for birds in the UK.

Table 1: Thresholds used to define individual species trends

Category	Thresholds	Threshold – equivalent
Strong increase	Above +2.81% per annum	+100% over 25 years
Weak increase	Between +1.16% and +2.81% p.a.	+33% to +100% over 25 years
Stable	Between -1.14 % and +1.16% p.a.	-25% to +33% over 25 years
Weak decrease	Between -2.73% and -1.14% p.a.	-50% to -25% over 25 years
Strong decrease	Below -2.73% p.a.	-50% over 25 years

Asymmetric percentage change thresholds are used to define these classes as they refer to proportional change, where a doubling of a species index (an increase of 100%) is counterbalanced by a halving (a decrease of 50%).

Results

The indicator for wild bees, hoverflies and all pollinators have been updated and the time series were extended by three additional years to 2022.

- The indicator (Figure 1) shows the average relative change in the area over which each of 394 species of pollinator was found, as measured by the number of 1km grid squares across the UK in which they were recorded – this is referred to as the 'occupancy index'.
- Over the long term (1980 to 2022), the pollinator indicator showed a 24% decline, and was therefore assessed as declining.
- Temporal patterns of change in the pollinator indicator showed a steady decline from 1987 onwards.
- Between 2017 and 2022 the indicator is assessed as "stable", showing little to no change.
- Over the long term, 19% of pollinator species became more widespread (8% showed a strong increase), and 42% became less widespread (21% showed a strong decrease).
- Over the short term, a greater proportion of species were increasing (39%; with 23% exhibiting a strong increase) than decreasing (36%; with 24% exhibiting a strong decrease).
- As individual pollinator species become more or less widespread, the communities in any given area become more or less diverse, and this may have implications for pollination as more diverse communities are, in broad terms, more effective in pollinating a wide range of crops and wild flowers.

The indicator plot was also produced for the bee (Figure 2) and hoverfly (Figure 3) species separately.

The wild bee index fluctuates around its initial value over much of the time-series until 2015 when it starts increasing. The indicator is 18% higher in 2022 than in 1980 and is assessed as "increasing". A larger proportion of bee species had increased than decreased over the long term (31% increased and 26% decreased), as well as over the short term (56% increased and 10% decreased).

With regard to hoverflies, the index was at a peak in 1987 (18% over its 1980 value), and then (apart from some minor increases), underwent a progressive decline. Thus, the indicator is approximately 44% lower in 2022 than in 1980. Over the short term (2017 to 2022), the indicator decreases by just over 4%. A greater proportion of hoverflies have declined than increased in occupancy over both the long and short term (1980 to 2022: 51% decreased and 12% increased;
2017 to 2022: 53% decreased and 29% increased). It is not clear why hoverflies show a different trend to bees, although differences in the life cycle will mean they respond differently to weather events and habitat change.

Figure 1: Change in the distribution of wild pollinators (n = 394) in the UK between 1980 and 2022. The shaded region is the 90% credible intervals of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates the rescaled indicator value. The proportion of pollinator species in each trend category is based on the mean annual change in occupancy over both a) the long term (1980 to 2022) and b) the short term (2017 to 2022).

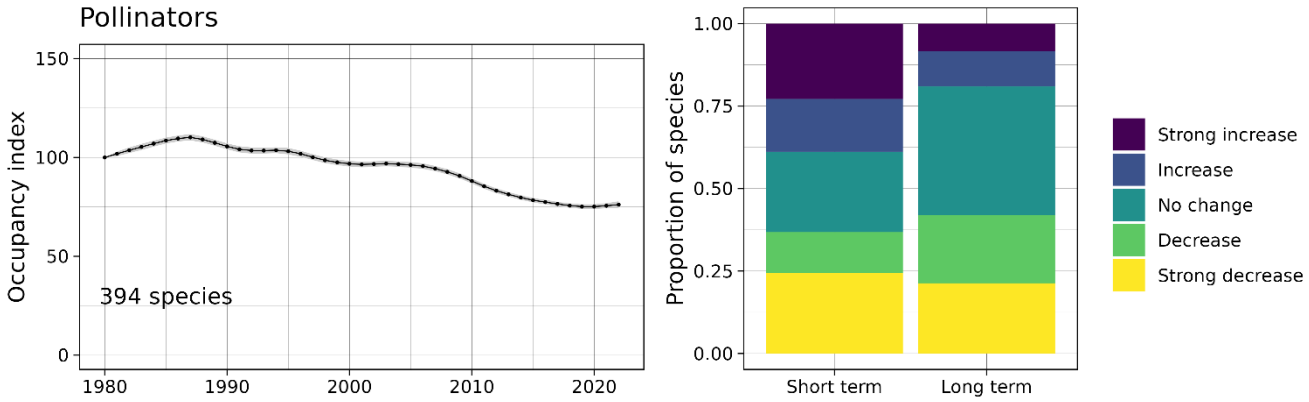


Figure 2: Change in the distribution of pollinating wild bee species (n = 158) in the UK between 1980 and 2022. The shaded region is the 90% credible intervals of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates the rescaled indicator value. The proportion of pollinator species in each trend category is based on the mean annual change in occupancy over both a) the long term (1980 to 2022) and b) the short term (2017 to 2022).

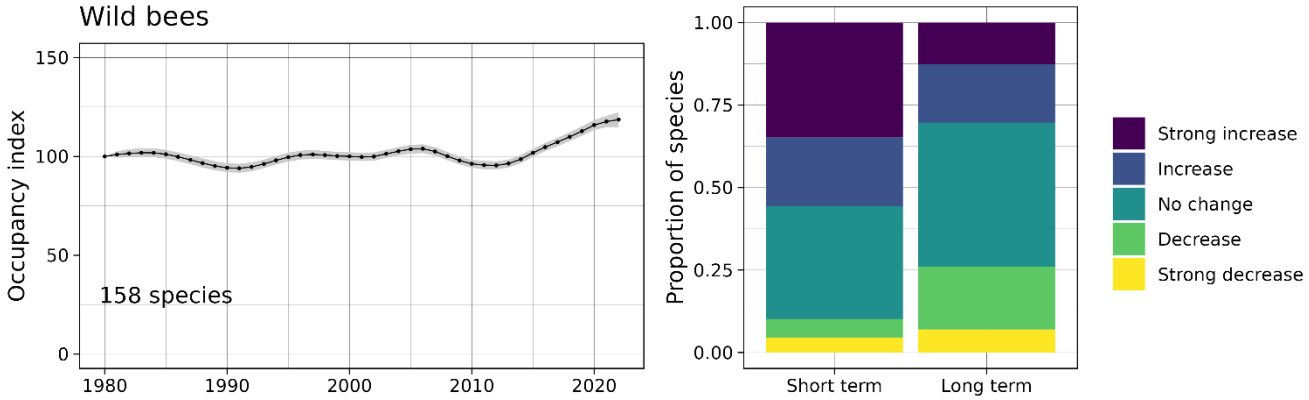
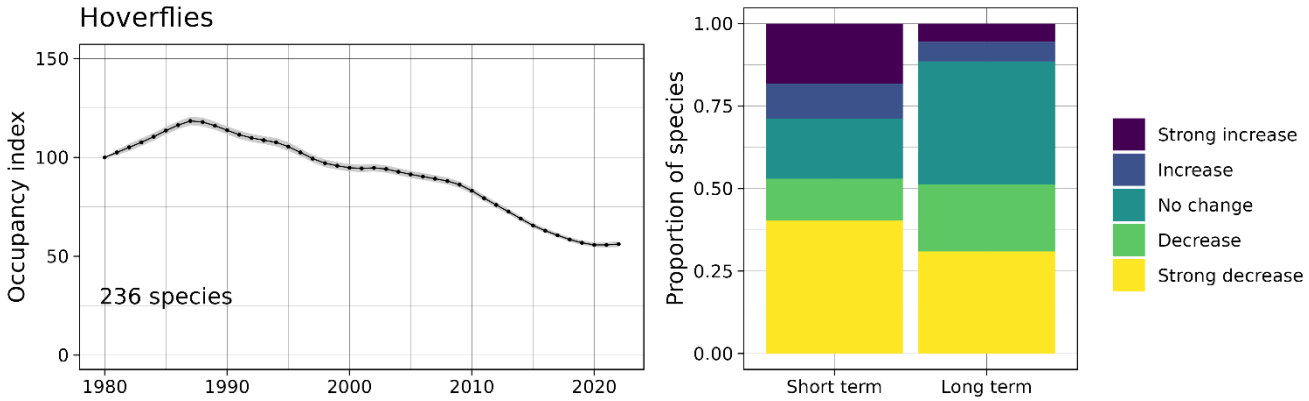


Figure 3: Change in the distribution of hoverfly species (n = 236) in the UK between 1980 and

2022. The shaded region is the 90% credible intervals of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates the rescaled indicator value. The proportion of pollinator species in each trend category is based on the mean annual change in occupancy over both a) the long term (1980 to 2022) and b) the short term (2017 to 2022).



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Appendices

Appendix 1: The list of the 394 species included in the pollinator indicator.

Species
Andrena alfkenella
Andrena ampla
Andrena angustior
Andrena apicata
Andrena argentata
Andrena barbilabris
Andrena bicolor
Andrena bimaculata
Andrena bucephala
Andrena chrysosceles
Andrena cineraria
Andrena clarkella
Andrena coitana
Andrena confinis
Andrena denticulata
Andrena dorsata
Andrena falsifica
Andrena ferox
Andrena flavipes
Andrena florea
Andrena fucata
Andrena fulva
Andrena fulvago
Andrena fuscipes
Andrena gravida
Andrena haemorrhoa
Andrena hattorfiana
Andrena helvola
Andrena humilis
Andrena labialis
Andrena labiata
Andrena lapponica
Andrena marginata
Andrena minutula
Andrena minutuloides
Andrena nigriceps
Andrena nigroaenea
Andrena nitida
Andrena nitidiuscula
Andrena niveata
Andrena pilipes

Andrena praecox
Andrena proxima
Andrena rosae
Andrena ruficrus
Andrena russala
Andrena semilaevis
Andrena simillima
Andrena subopaca
Andrena synadelpha
Andrena tarsata
Andrena thoracica
Andrena tibialis
Andrena vaga
Andrena varians
Andrena wilkella
Anthidium manicatum
Anthophora bimaculata
Anthophora furcata
Anthophora plumipes
Anthophora quadrimaculata
Anthophora retusa
Bombus distinguendus
Bombus hortorum
Bombus humilis
Bombus hypnorum
Bombus jonellus
Bombus lapidarius
Bombus lucorum
Bombus muscorum
Bombus pascuorum
Bombus pratorum
Bombus ruderarius
Bombus ruderatus
Bombus soroeensis
Bombus subterraneus
Bombus sylvarum
Bombus terrestris
Ceratina cyanea
Chelostoma campanularum
Chelostoma florisomne
Colletes cunicularius
Colletes daviesanus
Colletes floralis
Colletes fodiens
Colletes halophilus

Colletes hederae
Colletes marginatus
Colletes similis
Colletes succinctus
Dasypoda hirtipes
Eucera longicornis
Halictus confusus
Halictus eurygnathus
Halictus rubicundus
Halictus tumulorum
Heriades truncorum
Hoplitis adunca
Hoplitis claviventris
Hylaeus annularis
Lasioglossum albipes
Lasioglossum angusticeps
Lasioglossum brevicorne
Lasioglossum calceatum
Lasioglossum cupromicans
Lasioglossum fratellum
Lasioglossum fulvicorne
Lasioglossum laevigatum
Lasioglossum laticeps
Lasioglossum lativentre
Lasioglossum leucopus
Lasioglossum leucozonium
Lasioglossum malachurum
Lasioglossum minutissimum
Lasioglossum morio
Lasioglossum nitidiusculum
Lasioglossum parvulum
Lasioglossum pauperatum
Lasioglossum pauxillum
Lasioglossum prasinum
Lasioglossum punctatissimum
Lasioglossum puncticolle
Lasioglossum quadrinotatum
Lasioglossum rufitarse
Lasioglossum semilucens
Lasioglossum sexnotatum
Lasioglossum smeathmanellum
Lasioglossum villosulum
Lasioglossum xanthopus
Lasioglossum zonulum
Macropis europaea

Megachile centuncularis
Megachile circumcincta
Megachile leachella
Megachile ligniseca
Megachile maritima
Megachile versicolor
Megachile willughbiella
Melitta dimidiata
Melitta haemorrhoidalis
Melitta leporina
Melitta tricincta
Nomada bifasciata
Nomada facilis
Osmia aurulenta
Osmia bicolor
Osmia bicornis
Osmia caerulescens
Osmia leaiana
Osmia parietina
Osmia pilicornis
Osmia spinulosa
Osmia uncinata
Osmia xanthomelana
Panurgus banksianus
Panurgus calcaratus
Stelis odontopyga
Xylocopa violacea
Anasimyia contracta
Anasimyia interpuncta
Anasimyia lineata
Anasimyia lunulata
Anasimyia transfuga
Arctophila superbiens
Baccha elongata
Blera fallax
Brachyopa bicolor
Brachyopa insensilis
Brachyopa pilosa
Brachyopa scutellaris
Brachypalpoides lentus
Brachypalpus laphriformis
Caliprobola speciosa
Callicera aurata
Callicera rufa
Callicera spinolae
Chalcosyrphus eunotus

Chalcosyrphus nemorum
Chamaesyrphus scaevoides
Cheilosia albipila
Cheilosia antiqua
Cheilosia barbata
Cheilosia bergenstammi
Cheilosia caerulescens
Cheilosia carbonaria
Cheilosia chrysocoma
Cheilosia cynocephala
Cheilosia fraterna
Cheilosia griseiventris
Cheilosia grossa
Cheilosia illustrata
Cheilosia impressa
Cheilosia lasiopa
Cheilosia latifrons
Cheilosia longula
Cheilosia mutabilis
Cheilosia nebulosa
Cheilosia nigripes
Cheilosia pagana
Cheilosia proxima
Cheilosia pubera
Cheilosia scutellata
Cheilosia semifasciata
Cheilosia soror
Cheilosia urbana
Cheilosia variabilis
Cheilosia velutina
Cheilosia vernalis
Cheilosia vicina
Cheilosia vulpina
Chrysogaster cemiteriorum
Chrysogaster solstitialis
Chrysogaster virescens
Chrysotoxum arcuatum
Chrysotoxum bicinctum
Chrysotoxum cautum
Chrysotoxum elegans
Chrysotoxum festivum
Chrysotoxum vernale
Chrysotoxum verralli
Criorhina asilica
Criorhina berberina

Criorhina floccosa
Criorhina ranunculi
Dasysyrphus albostriatus
Dasysyrphus friuliensis
Dasysyrphus hilaris
Dasysyrphus neovenustus
Dasysyrphus pinastri
Dasysyrphus tricinctus
Dasysyrphus venustus
Didea fasciata
Didea intermedia
Doros profuges
Epistrophe diaphana
Epistrophe eligans
Epistrophe grossulariae
Epistrophe melanostoma
Epistrophe nitidicollis
Episyrphus balteatus
Eriozona erratica
Eriozona syrphoides
Eristalinus aeneus
Eristalinus sepulchralis
Eristalis abusivus
Eristalis arbustorum
Eristalis cryptarum
Eristalis horticola
Eristalis interruptus
Eristalis intricarius
Eristalis pertinax
Eristalis rupium
Eristalis similis
Eristalis tenax
Eumerus funeralis
Eumerus ornatus
Eumerus sabulonum
Eumerus strigatus
Eupeodes bucculatus
Eupeodes corollae
Eupeodes lapponicus
Eupeodes latifasciatus
Eupeodes luniger
Eupeodes nielseni
Eupeodes nitens
Ferdinandea cuprea
Ferdinandea ruficornis

Hammerschmidtia ferruginea
Helophilus hybridus
Helophilus pendulus
Helophilus trivittatus
Heringia heringi
Heringia latitarsis
Heringia pubescens
Heringia senilis
Heringia vitripennis
Lejogaster metallina
Lejogaster tarsata
Lejops vittatus
Leucozona glaucia
Leucozona laternaria
Leucozona lucorum
Mallota cimbiciformis
Melangyna arctica
Melangyna cincta
Melangyna compositarum
Melangyna labiatarum
Melangyna lasiophthalma
Melangyna quadrimaculata
Melangyna umbellatarum
Melanogaster aerosa
Melanogaster hirtella
Melanostoma dubium
Melanostoma mellinum
Melanostoma scalare
Meligramma euchromum
Meligramma guttatum
Meligramma triangulifera
Meliscaeva auricollis
Meliscaeva cinctella
Merodon equestris
Microdon analis
Microdon devius
Myathropa florea
Myolepta dubia
Neoascia geniculata
Neoascia interrupta
Neoascia meticulosa
Neoascia obliqua
Neoascia podagrica
Neoascia tenur
Orthonevra brevicornis
Orthonevra geniculata

Orthonevra intermedia
Orthonevra nobilis
Paragus haemorrhous
Paragus tibialis
Parasyrphus annulatus
Parasyrphus lineola
Parasyrphus malinellus
Parasyrphus nigritarsis
Parasyrphus punctulatus
Parasyrphus vittiger
Parhelophilus consimilis
Parhelophilus frutetorum
Parhelophilus versicolor
Pelecocera tricincta
Pipiza austriaca
Pipiza bimaculata
Pipiza fenestrata
Pipiza lugubris
Pipiza luteitarsis
Pipiza noctiluca
Pipizella viduata
Pipizella virens
Platycheirus albimanus
Platycheirus ambiguus
Platycheirus angustatus
Platycheirus discimanus
Platycheirus fulviventris
Platycheirus granditarsus
Platycheirus immarginatus
Platycheirus manicatus
Platycheirus occultus
Platycheirus perpallidus
Platycheirus podagratus
Platycheirus rosarum
Platycheirus scambus
Platycheirus splendidus
Platycheirus sticticus
Platycheirus tarsalis
Pocota personata
Portevinia maculata
Psilota anthracina
Rhingia campestris
Rhingia rostrata
Riponnensia splendens
Scaeva pyrastri
Scaeva selenitica
Sericomyia lappona
Sericomyia silentis

Sphaerophoria batava
Sphaerophoria fatarum
Sphaerophoria interrupta
Sphaerophoria philanthus
Sphaerophoria rueppellii
Sphaerophoria scripta
Sphaerophoria taeniata
Sphaerophoria virgata
Sphegina clunipes
Sphegina elegans
Sphegina sibirica
Sphegina verecunda
Syritta pipiens
Syrphus ribesii
Syrphus torvus
Syrphus vitripennis
Trichopsomyia flavitarsis
Triglyphus primus
Tropidia scita
Volucella bombylans
Volucella inanis
Volucella inflata
Volucella pellucens
Volucella zonaria
Xanthandrus comtus
Xanthogramma citrofasciatum
Xylota abiens
Xylota florum
Xylota jakutorum
Xylota segnis
Xylota sylvarum
Xylota tarda
Xylota xanthocnema