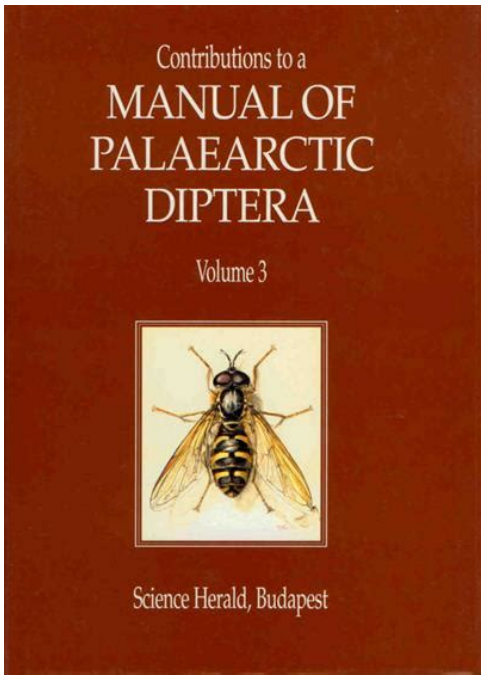

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For each species, the following data are given the date of the original description, reference to the latest redescription with morphological illustrations, detailed list of the label data of examined material, and general distribution. In the list of the material examined, geographical names are given according to their spelling in the labels. Petersburg, 199034, Russia V. F. Zaitzev Authors V. F. Zaitzev View author publications You can also search for this author in. Please enable JavaScript, then refresh this page. JavaScript is required on this site.The genera and species included are those which have a significant importance as model organisms in genetics, as plant pests or beneficial organisms in agriculture, and as vectors of animal and human diseases. Morphological keys with many figures for adults and larvae are given. Volume 1 will concern general and applied dipterology and is expected in 1998. Volume 3 will present the Higher Brachycera and will be published in 1999. The EU Commission is not responsible for any use that may be made of the information from these projects subsequently included in the EPPO Global Database. Bishops University. Sherbrooke. Canada, Canadian Museum of Nature. Ottawa. Canada, Canadian Food Inspection Agency. Canada, Royal British Columbia Museum. Salmon Arm. Canada, Agriculture and AgriFood Canada. Canada, Mississippi State University. Starksville. United States of America, Royal Ontario Museum. Toronto. Canada, University of Guelph. Guelph. Victoria. Canada, California Department of Food and Agriculture. Sacramento. United States of America, Royal British Columbia Museum. Canada,

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Sinclair, Jeffrey H. Skevington This is an open access article distributed under the terms of the CC0 Public Domain Dedication. This article has been cited by other articles in PMC. Abstract The Canadian Diptera fauna is updated. Numbers of species currently known from Canada, total Barcode Index Numbers BINs, and estimated numbers of undescribed or unrecorded species are provided for each family. An overview of recent changes in the systematics and Canadian faunistics of major groups is provided as well as some general information on biology and life history. A total of 116 families and 9620 described species of Canadian Diptera are reported, representing more than a 36% increase in species numbers since the last comparable assessment by JF McAlpine et al. 1979. Almost 30,000 BINs have so far been obtained from flies in Canada. Estimates of additional number of species remaining to be documented in the country range from 5200 to 20,400. Keywords biodiversity assessment, Biota of Canada, The world fauna of Diptera counts almost 160,000 named species Borkent et al. 2018 divided into approximately 160 extant families Pape and Thompson 2013 . Flies dominate the Canadian insect fauna in numbers of named species and, in many habitats, in overall abundance. That dominance becomes especially apparent in the northern parts of the country where dipterans form a ubiquitous feature of the summer landscape. Diptera occur in almost all freshwater and terrestrial habitats where they display an impressive range of life histories and feeding habits. From parasites to leafminers, predators and filter feeders to mention only a few, flies have diversified to exploit almost all organic substrates for their development see Courtney et al. 2017 and Marshall 2012 for detailed overviews. Canada holds approximately 20% of the world's freshwater reserves so, unsurprisingly, families with aquatic stages are very well represented in the country. BINs 3 available for Canadian species Est.

no. undescribed or unrecorded species in Canada General distribution by ecozone 3A Information sources Subsequently, the three volumes of the Manual of Nearctic Diptera JF McAlpine et al. 1981, 1987, JF McAlpine and Wood 1989 have been major catalysts for dipterological research in Canada and the USA. A detailed overview of these contributions, and the people who made them possible, was provided in Cumming et al. 2011. The identification keys to genus found in Volumes 1 and 2 JF McAlpine et al. 1981, 1987 paved the way for future taxonomic work on the Nearctic fauna, and for many families they remain the best identification resource. While recent catalogues are now available for a number of Nearctic Diptera families, e.g., Dolichopodidae Pollet et al. 2004 and Tachinidae O'Hara and Wood 2004 , no comprehensive catalogue has been published for the Canadian fauna of the whole order since Stone et al. 1965. The global online database, Systema Dipterorum Pape and Thompson 2013 , provides extensive information about Diptera names and literature; it is especially useful for resolving issues related to precedence and validity of names during taxonomic revisions. As with many arthropod groups, the development of DNAbased identification and phylogenetic tools has had a strong impact on Diptera systematics. However, gaps and errors in existing barcode libraries in some freshwater taxa Curry et al. 2018 , as well as poor correspondence between COI DNA barcodes and morphology for at least one genus found in Canada Protocalliphora Hough; Whitworth et al. 2007 warrant caution when using BINs alone as estimates of true Diptera species diversity. The Manual of Nearctic Diptera, especially Volume 3 McAlpine and Wood 1989 , also had a major impact on the field of Diptera phylogenetics.

The hypotheses of familylevel relationships and the proposed classification presented have served as a basis for future updates Yeates and Wiegmann 2012 and have since been tested repeatedly using new sources of data and continuously evolving quantitative methods see Wiegmann and Yeates 2017

for review. It is notable that while the last three decades have generated an impressive body of literature on Diptera phylogenetics, a lack of consensus still remains in many parts of the Diptera phylogeny Borkent 2018 . Consequently, the family concepts used in the present work follow Pape et al. 2011 but the classification reflects a consensus of opinions of coauthors and collaborators who have contributed data to this paper. The numbers of recorded and named species have also increased since 1979 for most families, with the exception of those that were split e.g., Tipulidae and Empididae or those in which numerous synonymies were uncovered e.g., Bibionidae . Especially worth noting are the Sphaeroceridae and Anthomyzidae, with five and ninefold increases in species numbers since 1979, respectively. In each of these cases, the impressive increase in species numbers can be attributed to decadeslong dedication to biosystematics study of particular families by individuals and institutions S Marshall and colleagues at the University of Guelph, Ontario, for the Sphaeroceridae and K Barber at the Great Lakes Forestry Centre in Sault Ste. Marie, Ontario, for the Anthomyzidae . JF McAlpine et al. 1979 compiled 7056 species of Diptera in Canada mistakenly reported as 7058 in table 42 and estimated that an approximately equivalent number remained to be discovered. The 9620 species reported here represents a 36% increase since 1979. Significant advances have been made over the last four decades but some major gaps remain.

Nematocerous Diptera The nematocerous Diptera Lower Diptera , previously known as Nematocera, include those species of adult flies with elongate antennae composed of at least four flagellomeres. The group includes 36 extant families worldwide, of which 33 occur in Canada. As adults, nematocerous Diptera tend to be longlegged and, compared to brachyceran Diptera, weaker fliers. Larvae are found in a wide array of habitats and include a large number of aquatic and semiaquatic taxa see Tipulomorpha and Culicomorpha below, fungal feeders, gall makers, detritus feeders, predators, and even parasites, among others. The biting flies are mostly in the Culicomorpha and include those species that vector important diseases of humans, domestic animals and wildlife. The nematocerous Diptera are clearly paraphyletic in relation to the Brachycera, although the exact sister group of Brachycera within the nematocerous Diptera is not certain Woodley et al. 2009 . The phylogenetic relationships among families have also been, in part, rather unstable. The phylogenetic analysis by Wood and Borkent 1989 laid groundwork, which was largely supported by Oosterbroek and Courtney 1995. Michelsen 1996 proposed the Neodiptera, a clade including Axymyiidae, Pachyneuridae, Bibionidae, Sciaroidea, Perissommatidae, Scatopsoidea, Anisopodidae, and Brachycera based on characters of the adult prothorax and cervical sclerites. Molecular analyses have proposed a wide array of differing relationships that conflict with each other, at least in part, and with most morphological analyses Pawlowski et al. 1996, Friedrich and Tautz 1997, Miller et al. 1997, Bertone et al. 2008 . Wiegmann et al. 2011 and Lambkin et al. 2013 have provided the most recent overall interpretation of family relationships based on both morphological and molecular evidence, but these have major issues of interpretation Borkent 2018 . See below for summaries of the limits and phylogeny of the infraorders.

Infraorder Tipulomorpha F Brodo The major change to this infraorder since JF McAlpine et al. 1979 is the division of the Tipulidae into four families Tipulidae, Cylindrotomidae, Limoniidae, and Pediciidae. Most European workers had recognized the family status of the first three taxa for decades, as Byers 1992 carefully documented while still favouring the inclusion of all craneflies in a single family. The recognition of four families of crane flies remains a contentious issue among taxonomists. Molecular analyses Bertone et al. 2008, Wiegmann et al. 2011 as well as a recent morphological study Lukashevich and Ribeiro 2018 indicate that Limoniidae are paraphyletic, thereby calling into question the family ranking of these crane fly taxa. In the present work we have decided to follow the fourfamily concept, mostly to remain aligned with the classification used in the

online Catalogue of the Craneflies of the World Oosterbroek 2018 and BOLD. Tipulomorpha also include Trichoceridae winter crane flies, a small family now formally recognized as the sister group to the Tipulidae s. lat. crane flies Bertone et al. 2008, Wiegmann et al. 2011, Wiegmann and Yeates 2017 . Crane flies are mostly aquatic or semiaquatic but a few, notably the pest species, are terrestrial and associated with roots of grasses and herbaceous plants. Many larvae are saprophagous, fungivorous, Limonia Meigen and Metalimnobia Matsumura species, or carnivorous some Limoniidae and Pediciidae species, and Cylindrotomidae are phytophagous. Tipula paludosa Meigen and T. oleracea Linnaeus are established pests of dairy lands and golf courses Gelhaus 2001 . The larvae of winter crane flies feed on detritus and fungi and are often associated with small animal burrows or bird's nests Dahl 1973 . Nymphomyiidae and Deuterophlebiidae BJ Sinclair The placement of these two families remains controversial. Only one species of minute Nymphomyiidae Courtney 1994 .

The second nymphomyiid species listed in JF McAlpine et al. 1979 was reinterpreted and transferred to Chironomidae Kevan and Cutten 1981 . Infraorder Psychodomorpha G Curler and BJ Sinclair The limits of the Psychodomorpha have either been based on adult thoracic features Hennig 1973, JF McAlpine et al. 1979 or defined by a suite of larval characters Wood and Borkent 1989 . The latter grouping has been viewed as a heterogeneous assemblage of non Neodiptera Psychodidae, Trichoceridae and Neodiptera Perissommatidae, Anisopodidae and Scatopsoidea families Michelsen 1996 . Recent analyses support a threefamily concept, namely Blephariceridae, Psychodidae and Tanyderidae Bertone et al. 2008, Wiegmann et al. 2011 ; however, these families did not form a clade in the analyses in Lambkin et al. 2013. Additional support for a relationship between Psychodidae and Tanyderidae is based on wing venation Bertone et al. 2008, Borkent and Sinclair 2012 . The three family concept of this infraorder is followed here. Most species of Nearctic Psychodinae are detritivores living among moist decaying plant material or in madicolous habitats along stream margins, headwaters or seeps. In addition, several species of Psychodinae occur in homes and other habitats with anthropogenic influence e.g., sewage treatment facilities, latrines, farmyards, polluted drainages. Infraorder Ptychopteromorpha BJ Sinclair Wood and Borkent 1989 proposed the infraorder Ptychopteromorpha for two small families of flies, Ptychopteridae and Tanyderidae. Molecular and morphological evidence supporting the transfer of the Tanyderidae to the Psychodomorpha Bertone et al. 2008, Borkent and Sinclair 2012 , has resulted in this infraorder being represented solely by the family Ptychopteridae. Phylogenetic relationships among the families of Culicomorpha are well known and have considerable support Borkent 2012, Kutty et al.

2018 but the position of Chironomidae needs further testing, as either the sister group of all remaining families, or as the sister group of Ceratopogonidae. The remaining four families have some or all species with biting females. The medical and veterinary significance and dominant presence in aquatic systems of so many Culicomorpha has meant that they are some of the best known of the Diptera, including interpretation of their immatures. Dixidae are poorly understood and require fundamental revision Greenwalt and Moulton 2016 . Immature Culicomorpha are aquatic in both lotic and lentic habitats where they are prey for aquatic organisms, including fish. The Chironomidae are especially common, occupying virtually every aquatic niche, including tree holes, rivers, lakes, and even tidal habitats where their abundant larvae often have a strong influence on aquatic community structure. As adults, the Culicidae are the most prevalent, ubiquitous and persistent blood feeders in Canada, where some species are vectors of arboviruses, including West Nile virus, currently the most common mosquitoborne infection of humans in the country Roth et al. 2010 . Simuliidae are also quite common and sometimes very abundant in large rivers and lake outlets, with the resulting blood feeding activities affecting both humans and livestock. Most Ceratopogonidae are predaceous but the majority of Culicoides Latreille species have biting females. One species, C. sonorensis Wirth and Jones, is a vector of Bluetongue virus of cattle and other ruminants in southcentral British Columbia Sellers and Maarouf 1991 . Female

Corethrellidae are known only to bite frogs. Axymyiidae BJ Sinclair The phylogenetic relationships and systematic assignment of the family remains disputed Sinclair 2013 . The life history of the eastern Nearctic A. furcata is well documented Wihlm and Courtney 2011 and all known larval stages in Axymyiidae are restricted to burrowing in waterpermeated wood.

Infraorder Bibionomorpha s. lat. BJ Sinclair The boundaries of the Bibionomorpha have revolved around the nematocerous families included in the Neodiptera by Michelsen 1996, but there has been little consensus. Hennig 1973 favoured a broad concept that included the Bibionidae, Pachyneuridae, Sciaroidea, Scatopsoidea, Anisopodidae, Axymyiidae, and Perissommatidae nonNearctic, whereas Wood and Borkent 1989 restricted the infraorder to Bibionidae, Pachyneuridae, and Sciaroidea. Amorim 1993 included the following groups in the Bibionomorpha Bibionidae, Pachyneuridae in part, Sciaroidea, and Anisopodidae. More recently molecular analyses have again supported the broad concept sensu Hennig 1973, exclusive of Perissommatidae Wiegmann et al. 2011 or exclusive of both Perissommatidae and Axymyiidae Bertone et al. 2008 . Grimaldi and Engel 2005 also recognized a broad concept, although exclusive of Scatopsoidea. The Anisopodidae have not received much recent taxonomic attention in the Nearctic, although species of Sylvicola Harris were revised by Pratt and Pratt 1980. The larvae of these families are saprophagous and found in moist decaying organic matter. The remaining three families are much more diverse. The great diversity of this family is in part due to the apparent host specificity of plantfeeding species, with several of economic importance. The genera of Mycetophilidae can be keyed in Vockeroth 1981, but some subfamilies are now recognized as families see above. Members of the Bibionomorpha s. str. are most abundant in moist woodlands, with many larvae found in fungi, in dead wood and other decaying plant material, beneath bark, and in a variety of other microhabitats. The majority of Cecidomyiidae are associated with plants, forming galls or developing in flowers and leaf rolls, whereas others are inquilines on plant hosts damaged by other gall midges. Some are also associated with fungi, or freeliving predators.

The Lower Brachycera are a large and undoubtedly unnatural assemblage of mostly large and conspicuous flies. Until recently, this group was widely referred to as the Orthorrhapha, but morphological and molecular evidence indicate that it is paraphyletic, at least with respect to the Cyclorrhapha Woodley 1989 . With the assignment of the Empidoidea to the Eremoneura which includes both Cyclorrhapha and Empidoidea Griffiths 1972 , the term Lower Brachycera is now used to refer to the nonEremoneuran Brachycera. Major changes since JF McAlpine et al. 1979 include the recognition of a new family Oreoleptidae Zloty et al. 2005 and elevation of the Bolbomyiidae Kerr 2010 and Mythicomyiidae Evenhuis 2002 from Rhagionidae and Bombyliidae, respectively. Infraorder Xylophagomorpha BJ Sinclair This infraorder is represented by the single family Xylophagidae, although some authors have divided it into smaller family units Woodley 1989 . Xylophagids are found primarily in wooded and forest regions where the larvae are predators of wood inhabiting insects. Infraorder Tabanomorpha BJ Sinclair Woodley 1989 and Sinclair et al. 1994 summarized the morphological evidence for relationships of the Tabanomorpha. Much of the uncertainty of higher level phylogeny of the Tabanomorpha is due to doubts concerning the limits and monophyly of the Rhagionidae. Through combined morphological and molecular analyses, Kerr 2010 redefined the family Rhagionidae, establishing its monophyly and recognizing the families Austroleptidae Australia and Chile and Bolbomyiidae. The classification of Kerr 2010 is followed here. Six families of Tabanomorpha occur in Canada and these are organized in two superfamilies. Adults are common in forested regions, where most larvae occur in damp forest litter and beneath mats of mosses. The immature stages of the Bolbomyiidae are unknown.

With the slight increase in species richness since 1979, this family is now considered to be very well known and no additional species are expected in Canada. Those of Pelecorhynchidae and Tabanidae are predators of invertebrates found mostly in wetland soils. Infraorder Stratiomyomorpha M Hauser

The infraorder Stratiomyomorpha includes three families, of which the Stratiomyidae and the Xylomyidae occur in Canada while the Pantophthalmidae are restricted to the Neotropics. The sistergroup relationship of Stratiomyidae and Xylomyidae is strongly supported, especially by larval characters Woodley 1989 . Stratiomyids are usually found in humid and forested areas where their larvae are terrestrial or aquatic, feeding mostly on decaying plant and animal materials Woodley 2001 . The larvae of Xylomyidae are found under the bark of trees but little is known of the biology of these uncommon flies. Acroceridae and Nemestrinidae BJ Sinclair Both families have been assigned to the Nemestrinoidea based on the parasitic larvae with hypermetamorphosis Woodley 1989 , but this infraorder including Bombyliidae is now generally considered polyphyletic with the three parasitic families considered to be distantly related Yeates 1994, 2002, Winterton et al. 2007, Wiegmann et al. 2011, but see Shin et al. 2017 for a divergent opinion. Twenty species of Acroceridae are recorded from Canada; a key to New World genera is available in Schlinger et al. 2013, but only one recent revision has included Canadian records Borkent et al. 2016 . A few more acrocerid species are therefore expected in the country. The larvae of Acroceridae are internal parasites of spiders, whereas those of Nemestrinidae are parasitic on grasshoppers and beetles. The Asilomorpha display a wide range of habitats and life histories. The Scenopinidae have predaceous larvae associated with woodboring larvae, bird’s nests, and carpet beetle larvae.

The larvae of Hilarimorphidae are unknown and adults are sporadically collected, with verified records indicating that they frequent riverbanks. Adult Mythicomyiidae are flower visitors, feeding on pollen and nectar, whereas the few larval observations suggest egg pod predators of grasshoppers and inquilines in ant nests. Adult Asilidae are efficient predators with highly modified mouthparts; the larvae live in soils and rotting wood. Larvae of Therevidae are often found burrowing through sandy soils Irwin and Lyneborg 1981 . The larvae of Mydidae and Apioceridae are predaceous in sandy soils and adults are flower feeders. The Bombyliidae are generally parasitic on various Holometabola or predaceous on egg pods of grasshoppers Hall 1981 , with adults visiting flowers. Some authors have treated two of these genusgroups as separate families i.e., Homalocnemidae nonNearctic and Oreogetonidae , because of the availability of familygroup names Thompson 2009, Pape et al. 2011, Marshall 2012 . The Iteaphila group has recently been elevated to subfamily rank within yet another newly recognized Empidoidea family, Ragadidae Wahlberg and Johanson 2018 . Recognition of this family is controversial and generally not accepted by the empidoid community, nor is it accepted herein. Apart from the Dolichopodidae exclusive of Microphorinae and Parathalassiinae , the remaining groups were lumped into the Empididae in JF McAlpine et al. 1979. The current total of 949 Canadian species of Empidoidea is a moderate increase over the 800 species recorded by JF McAlpine et al. 1979. Many empidoid genera still require study and recent Nearctic revisions e.g., Sinclair et al. 2011, Sinclair and MacDonald 2012, Brooks and Cumming 2017 have resulted in numerous new species descriptions. The key to the Nearctic genera of Empididae in Steyskal and Knutson 1981 follows the family concept used by JF McAlpine et al. 1979 and is now outofdate.

The Oreogetonidae and two subfamilies of Empididae Clinocerinae and Hemerodromiinae include species with aquatic larvae. The remaining Empididae are mainly terrestrial and many species are important pollinators Rader et al. 2016 , especially in alpine and arctic regions Lefebvre et al. 2014 . The Hybotidae are common predators in forests, grasslands and agricultural fields Sinclair and Cumming 2017 , whereas the Dolichopodidae are significant predators in various aquatic, semiaquatic and terrestrial habitats Grichanov and Brooks 2017 . Suborder Brachycera Eremoneura Cyclorrhapha The Cyclorrhapha constitute the most diverse lineage of Brachycera and include the numerous families of higher flies that pupate inside the last larval exuviae i.e., puparium. The group is divided into the basal Lower Cyclorrhapha “ Aschiza ” and the monophyletic Schizophora i.e., flies with a protrusible ptilinum for exiting the puparium. Schizophora are further divided into the paraphyletic Acalyptratae and the monophyletic Calyptratae. Lower Cyclorrhapha “ Aschiza ” No

recent hypotheses support the monophyly of the Aschiza, which traditionally included the cyclorrhaphan families exclusive of Schizophora or those flies without a ptilinum for exiting the puparium. Only Brown 1992, 1995 and Disney 1994 have supported the monophyletic Aschiza concept proposed by McAlpine 1989. All other morphological and molecular analyses have shown that the " Aschiza " are a grade and should be referred to as the Lower Cyclorrhapha Griffiths 1972, Cumming et al. 1995, Zatwarnicki 1996, Collins and Wiegmann 2002, Moulton and Wiegmann 2004, Wiegmann et al. 2011, Pauli et al. 2018 . This is an important lineage to understand phylogenetically as it sets the stage for the massive radiation of Schizophora. Unfortunately, there has been a profound lack of agreement about relationships within this grade.

Lonchopteridae J Skevington and JM Cumming Placement of Lonchopteridae has been one of the most intractable problems within Diptera phylogenetics. Larvae are found in wet, decaying organic matter where they feed on bacteria and fungi. Two species occur in aquatic environments such as springs, seeps and shorelines Valliant 2002 . Adults feed on fungi, nectar, pollen and dead insects Klymko and Marshall 2008 . Superfamily Platypezoidea J Skevington and JM Cumming The status of this superfamily is contentious and its use should probably be abandoned. Immature platypezids are fungivorous and the males of many species form large swarms. Superfamily Phoroidea J Skevington and JM Cumming Phylogenetic analyses that include the relevant taxa support the relationship of Phoridae including Sciadocerinae sensu Brown et al 2015, Disney 2001 and Ironomyiidae nonNearctic in this superfamily Wiegmann et al. 2011, Young 2018 . Although some of the most common species are decomposers including carrion feeders, others are fungivorous, phytophagous including leaf miners, inquilines in social insect nests, predators, or parasitoids. Superfamily Syrphoidea J Skevington This is another higher grouping that should likely be abandoned. Recently discovered morphological evidence based on metapleural characters Tachi 2014 supports the sistergroup relationship of Pipunculidae and Schizophora. Most adult syrphids are pollinators, but larvae range from predators of aphids and other softbodied insects, predators and parasitoids of ants, to saprophages in rotting wood, slime fluxes, and sewage. Most pipunculids are parasitoids of Auchenorrhyncha Skevington and Marshall 1997 and Nephrocerus Zetterstedt are parasitoids of Tipulidae Koenig and Young 2007 . Schizophora Acalyptratae The Schizophora are a large monophyletic subgroup of Cyclorrhapha characterized by an inflatable saclike ptilinum that temporarily extrudes from the head of the adult fly to allow emergence from the puparium.