

Araneae of Canada

Robb Bennett¹, Gergin Blagoev², Claudia Copley¹

1 Department of Entomology, Natural History Section, Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia, V8W 9W2, Canada **2** Centre for Biodiversity Genomics, University of Guelph, 579 Gordon Street, Guelph, Ontario, N1G 2W1, Canada

Corresponding author: Robb Bennett (Robb.Bennett@shaw.ca)

Academic editor: D. Langor | Received 3 May 2018 | Accepted 16 June 2018 | Published 24 January 2019

<http://zoobank.org/81B8F2F1-829C-4BB8-B8F9-1F6DAF4F049A>

Citation: Bennett R, Blagoev G, Copley C (2019) Araneae of Canada. In: Langor DW, Sheffield CS (Eds) The Biota of Canada – A Biodiversity Assessment. Part 1: The Terrestrial Arthropods. ZooKeys 819: 41–56. <https://doi.org/10.3897/zookeys.819.26391>

Abstract

In 1979 nearly 1400 spider species in 32 families either had been recorded (1249) or were believed to occur (~140) in Canada. Twenty years later, although significant progress had been made in survey efforts in some regions, Canada's spider inventory had only increased by approximately 7% to roughly 1500 species known or expected to occur. The family count had increased to 38 but only two additions were truly novel (five family additions and one family deletion were the result of advances in family-level systematics). The first comprehensive taxonomic checklist of Canadian spider species was published in 2010 documenting the regional distributions of 1376 species representing 42 families (three novel since 1999). From 2010 through 2017 new national records steadily accumulated resulting in the current (2018) Canadian inventory of 1477 species classified in 45 families (one novel since 2010). Although there has been close to a 20% increase in the number of spider species recorded in Canada since 1979, much greater increases have occurred in some of the regional species checklists, indicating increasing knowledge of the regional distribution of species previously recorded elsewhere in Canada. For example the regional checklists for Newfoundland, British Columbia, and Prince Edward Island have increased by 69%, 339%, and 520%, respectively. The national and regional increases reflect significant advances in the first two decades of the 21st Century in spider faunistics research in previously under-sampled habitats and regions and the development of molecular techniques and consequent barcoding of spiders. Of the 1477 species recorded in Canada, 92% have been successfully DNA barcoded resulting in 1623 unique Barcode Index Numbers (BINs). At least 25 of the BINs are associated with relatively easily distinguished but undescribed morpho-species. The majority, however, appear to indicate the existence of many cryptic species within Canada's known spider fauna. These data, coupled with the fact that novel Canadian or

even Nearctic spider species records (including of undescribed species) continue to accumulate annually (especially in habitat-diverse regions such as British Columbia), suggest that Canada's tally of spider species may approach or even exceed 1800.

Keywords

Araneae, BINs, biodiversity assessment, Biota of Canada, checklist, classification, DNA barcoding, faunistics, spiders

Introduction

Canadian national spider faunistics work commenced with Emerton's (1920) initial listing of the names of and basic locality data for the spider species then known to occur in Canada. Emerton's list was far from complete, reflecting the scant knowledge of Canada's spider fauna at that time. Nearly 60 years later the accumulation of sufficient data allowed production of the first reasonably comprehensive faunistic overview of the spiders of Canada (Dondale 1979). Subsequently, a series of increasingly detailed studies of the fauna has significantly improved the situation. Dondale (1979) provided the initial faunistics framework: a family-level table outlining general distributions and estimated species numbers for each, accompanied by a brief introduction to spiders, Canada's spider fauna, and basic biology of the major families.

Twenty years later, Bennett (1999) supplied a similar table with revised family-level nomenclature and species statistics, as well as more detailed family-level biology and comments on the then-current state of araneology in Canada. Subsequently, Paquin et al. (2010) published a checklist of all spider species found in Canada up to that date including species-level provincial and territorial distributional data, tables with summary family-level statistics, and a list of introduced species.

Most recently, the Canadian Endangered Species Conservation Council (2011, 2016) provided updated species-level checklists, including novel records and nomenclatural changes, as well as national and provincial/territorial conservation ranks for all species using NatureServe distribution and abundance analysis methodology (see Faber-Langendoen et al. (2012) for a description of NatureServe's methodology). Since then, two of us have maintained and updated the Canadian national and regional checklists (R Bennett and G Blagoev unpubl. data, summarised in Table 1). Unsurprisingly, the known Canadian spider fauna has been (and continues to be) dominated by species of Linyphiidae (Table 2).

Prior to 1979, regional spider species checklists existed for only two Canadian regions (Table 3): British Columbia (Thorne 1967, Bragg and Leech 1972) and the island of Newfoundland (Hackman 1954). Species-level data now exist for all Canadian provinces and territories (Table 3; Paquin et al. 2010) and a majority of these have series of three or more checklists showing increases in the accumulation of novel jurisdictional species records of greater than 20% (Alberta, Manitoba, Northwest Territories, Québec, and Yukon), nearly 70% (island of Newfoundland), to well over 300% (British Columbia) or 500% (Prince Edward Island).

Novel species records, including of undescribed species, continue to accumulate annually in Canada especially through the work of the University of Guelph's Centre for Biodiversity Genomics (CBG) at the national level and, regionally, where intensive spider inventory work is on-going, e.g., in British Columbia through the efforts of the Royal British Columbia Museum (RBCM). Ideally, faunistics research generates sufficient distribution and abundance data to allow for conservation ranking analyses. For more than one third of Canada's recorded spider species, however, only simple presence data exists and conservation ranks remain undetermined for those species. It is clear that much work remains to be done on Canadian spider faunistics. Canada's national and provincial/territorial spider species checklists will continue to grow, our knowledge of Canadian spider morphological and molecular taxonomy will continue to improve, and accumulating inventory data will allow for conservation ranking of a significant proportion of Canada's currently unranked spider fauna.

Here we present an overview of Canadian spider faunistics work from 1979 to 2018, focusing on the accumulation of national and regional species-level data. Classification follows Wheeler et al. (2017); nomenclature follows the World Spider Catalog (2018). Standard postal abbreviations are used for Canada's provinces and territories except for LB and NF, which refer to mainland Labrador and the island of Newfoundland, respectively: AB – Alberta, BC – British Columbia, MB – Manitoba, NB – New Brunswick, NS – Nova Scotia, NT – Northwest Territories, NU – Nunavut, ON – Ontario, PE – Prince Edward Island, QC – Québec, SK – Saskatchewan, and YT – Yukon.

In the beginning (Dondale 1979)

Although Emerton (1920) presented a cursory list, including basic locality data, of about 340 spider species then known to occur in Canada, the first serious summary of faunistics of Canada's spider species was published by Dondale (1979). The single table in that paper provided the faunistics framework for future studies of Canada's spider fauna: a list of the 32 families recorded to that date accompanied, for each family, with general Canadian ecological distribution data and the number of species known in Canada. Loxoscelidae (now Sicariidae), a 33rd family listed in the table, was then unrecorded in Canada and has not become established subsequently. Dondale predicted a total of about 1400 species for Canada's spider fauna: 1249 recorded (Table 3; number here revised down from 1256 because of enumeration errors in Dipluridae, Antrodiaetidae, Dysderidae, and Segestriidae (CD Dondale pers. comm.)) with a further 144 either known but undescribed or expected but not yet recorded.

Then, as is typical for the Holarctic region (Coddington and Levi 1991), entelegyne taxa, especially Linyphiidae (including Pimoidae and Dondale's "Erigonidae"), dominated the known Canadian spider fauna (Table 2): 445 of the species recorded (as well as more than half of the expected/undescribed species). Globally common and taxonomically fairly well-studied families accounted for a further 546 species (Table 2)

Table 1. Census of Araneae in Canada. Data as of March 2018 (R Bennett and G Blagoev unpubl. data). Primary references for all family-level and lower taxa are in the World Spider Catalog (2018) and Ubick et al. (2017).

Taxon ¹	No. species currently known from Canada ²	No. BINs ³ available for Canadian species	Distribution by ecozone ⁴
Suborder Opisthothelae			
Infraorder Mygalomorphae			
Superfamily Atypoidea			
Mecicobothriidae	1	1	Pacific Maritime
Antrodiaetidae	4	5	Pacific Maritime, southern Montane Cordillera
Atypidae	1	1	Mixedwood Plains
“Dipluroidea”			
Dipluridae	1	0	southern Montane Cordillera
Infraorder Araneomorphae			
Division Synspermiata⁵			
Superfamily Dysderoidea			
Segestriidae	1	1	southern Pacific Maritime
Dysderidae	1 (1)	2	southern Pacific Maritime, Mixedwood Plains; synanthropic
Oonopidae	2 (2)	0	southern Pacific Maritime, Mixedwood Plains; synanthropic
Superfamily Scytodoidea			
Scytodidae	2 (2)	1	Mixedwood Plains; synanthropic
“Pholcideoidea”			
Telemidae	1	3	Pacific Maritime, Montane Cordillera
Pholcidae	5 (3)	7	southern Montane Cordillera (native spp.); all southern ecozones (synanthropic spp.)
Division Entelegynae			
Superfamily Araneoidea			
Theridiidae	107 (19)	107	all ecozones
Anapidae	1	1	southern Pacific Maritime
Theridiosomatidae	1	2	Boreal Shield, Newfoundland Boreal, Mixedwood Plains, Atlantic Maritime
Araneidae	67 (5)	79	all ecozones
Pimoidae	3	5	Pacific Maritime, southern Montane Cordillera
Linyphiidae	569 (12)	624	all ecozones
Nesticidae	3 (1)	3	Pacific Maritime (native sp.), Mixedwood Plains (native and synanthropic spp.)
Mysmenidae	3	2	southern Pacific Maritime, southeastern Boreal Shield, and Mixedwood Plains
Mimetidae	9 (1)	7	all ecozones except Arctic
Tetragnathidae	26 (2)	72	all ecozones
Superfamily Oecobioidea			
Oecobiidae	2 (2)	0	southern Pacific Maritime, Mixedwood Plains; synanthropic
“Uloboroidea”			
Uloboridae	5 (1)	6	all ecozones south of Boreal Shield, Newfoundland Boreal, and Boreal Cordillera
“Titanoeoidea”			
Titanoecidae	4	4	all inland ecozones
Superfamily Zodarioidea⁶			
Zodariidae	1 (1)	1	southern Pacific Maritime, Mixedwood Plains; synanthropic
“Amaurobioidea”			
Amaurobiidae	14 (2)	13	all ecozones
“Desoidea”			
Desidae	1 (1)	0	Boreal Plains; synanthropic
Superfamily Agelenoidea⁷			
Dictynidae	62 (2)	79	all ecozones
Cybaecidae	22	24	Pacific Maritime, Montane Cordillera, Boreal Shield
Hahniidae	21	34	all ecozones
Agelenidae	20 (4)	15	all ecozones

Taxon ¹	No. species currently known from Canada ²	No. BINs ³ available for Canadian species	Distribution by ecozone ⁴
Superfamily Lycosoidea			
Oxyopidae	2	3	all southern ecozones
Thomisidae	66 (2)	81	all ecozones
Pisauridae	7	8	all ecozones
Lycosidae	104 (2)	103	all ecozones
“Salticoidea”⁸			
Salticidae	124 (7)	126	all ecozones
Philodromidae	47 (3)	54	all ecozones
Corinnidae	8	6	all southern ecozones
Eurichuridae	3 (1)	4	all southern ecozones
Miturgidae	1	1	southern Pacific Maritime, Montane Cordillera
“Anyphaenoidea”			
Anyphaenidae	7	8	all southern ecozones
Clubionidae	34 (2)	35	all ecozones
“Liocranoidea”			
Liocranidae	3	3	all ecozones
“Trochanterioidea”			
Trachelidae	3	6	southern Pacific Maritime, Mixedwood Plains, Atlantic Maritime
Phrurolithidae	16 (1)	14	all southern ecozones
Gnaphosidae	92 (3)	72	all ecozones including southern Arctic
Total	1477 (81)	1623	

¹Classification follows Wheeler et al. (2017); taxon names in quotation marks are informal. ²Parentheses enclose numbers of non-native species included in the total. ³Barcode Index Number (Ratnasingham and Hebert 2013). ⁴See figure 1 in Langor (2019) for a map of ecozones. ⁵Haplogynae of older classifications. ⁶Zodarioidea and all subsequent groups = “RTA Clade”. ⁷Dictynoidea of older classifications. ⁸“Salticoidea” and all subsequent groups = “Dionycha Clade” (within RTA Clade).

Table 2. Changes in numbers of species for selected spider families in Canada (1979–2018).

Family	1979 ¹	1999 ²	2010 ³	2016 ^{4,5}	2018 ⁶	Increase (decrease)
Theridiidae	93	100	99	102	107	14
Araneidae	69	74	57	58	67	(2)
Linyphiidae	445	>500	527	542	569	124
Tetragnathidae	21	23	25	25	26	5
Thomisidae	63	68	65	65	66	3
Lycosidae	90	110	101	99	104	14
Salticidae	100	110	108	110	124	24
Philodromidae	47	47	48	46	47	0
Gnaphosidae	63	~100	88	90	92	29

¹ Dondale 1979. ² Bennett 1999. ³ Paquin et al. 2010. ⁴ Canadian Endangered Species Conservation Council 2016. ⁵ Based on 2013 data. ⁶ R Bennett and G Blagoev unpubl. data.

representing, in combination with Linyphiidae, nearly 80% of the Canadian fauna. Species then classified in several other entelegyne families (especially Agelenidae, Dictynidae, Hahniidae, and Clubionidae) covered an additional approximately 15% but, because those families have proven to be non-monophyletic and subsequent species transfers have complicated the picture, family-level data for them from Dondale (1979) are not presented here. Families typical of warmer climates and/or austral regions, especially mygalomorph and synspermiata taxa (Dondale 1979), as well as a handful of entelegyne taxa, were represented by about two dozen species.

In 1979, only two Canadian jurisdictions, BC and NF (Table 3), had spider checklists, and these were not comprehensive for either province. Thorne (1967) listed 212 species in 20 families for BC, subsequently upgraded to 259 species by Bragg and Leech (1972). Thorne noted BC’s spider fauna was poorly known and implied that significant increases to the provincial checklist would result from better knowledge, in general, of the province’s northern interior and northern and eastern border areas and, in particular, of the province’s erigonine linyphiid fauna (see Bennett (2001) for a brief history of araneological work in BC from the late 1800s to 2001). Hackman (1954) documented 216 species (originally 220, revised down by Pickavance and Dondale (2005)) in 19 families for NF. Because his study was based almost entirely upon only two sets of collections made over two summers (1949, 1951) by visiting scientists from Fennoscandia, it is clear that Hackman’s (1954) checklist was not comprehensive.

Making progress (Bennett 1999)

Twenty years after Dondale’s (1979) treatment of the national fauna, Bennett (1999) updated Canadian family-level spider species statistics. Estimates, rather than exact counts, were made for most of the larger entelegyne families (e.g., Dictynidae – “75–80”, Linyphiidae – “> 500”) and the total number of species then recorded in Canada was estimated to be approximately 1400 (Table 3). Bennett (1999) speculated that the

Table 3. Changes in Canadian national, provincial, and territorial spider species numbers over time and percent increase since 2010.

Time period	AB	BC	LB	MB	NB	NF ¹	NS	NT	NU	ON	PE	QC	SK	YT	CAN	
1950–1979		212 ⁶ 259 ⁷				216 ²⁰									1249 ²⁷	
1980–1999		433 ⁸ 570 ⁹		483 ¹⁸								549 ²³ 620 ²⁴		297 ²⁶	~1400 ²⁸	
2000–2010		653 ¹⁰ 527 ² 601 ³	656 ¹¹	124 ³	531 ³	379 ³	363 ³	437 ³	267 ³	71 ³	746 ³	38 ³	677 ³	489 ³	335 ³	1376 ³
2011–2018		729 ¹³ 780 ¹⁴ 628 ⁴ 656 ⁵	213 ¹⁷ 859 ¹⁵ 877 ¹⁶	*	605 ⁴ 593 ¹⁹	390 ⁴ 416 ¹⁹	364 ⁴ *	446 ⁴ 472 ¹⁹	321 ⁴ 325 ¹⁹	96 ⁴ 98 ¹⁹	757 ⁴ 813 ¹⁹	44 ⁴ 198 ²²	666 ⁴ 691 ¹⁹	490 ⁴ 507 ¹⁹	357 ⁴ 366 ¹⁹	1399 ⁴ 1477 ¹⁹
% increase since 2010	10%	25%	71%	12%	10%	<1%	8%	22%	4%	9%	521%	2%	4%	9%	7%	

¹Excluding Labrador. ²Buckle and Holmberg in Pickavance and Dondale 2005. ³Paquin et al. 2010. ⁴Canadian Endangered Species Conservation Council 2016. ⁵R Bennett and G Blagoev unpubl. data. ⁶Thorne 1967. ⁷Bragg and Leech 1972. ^{8–9}West et al. 1984, 1988. ¹⁰Bennett 2001. ^{11–16}Bennett et al. 2006, 2010, 2012, 2014, 2017, unpubl. data. ¹⁷Perry et al. 2014, ¹⁸Aitchison-Benell and Dondale 1990. ¹⁹R Bennett and G Blagoev unpubl. data. ²⁰Hackman 1954 as revised in Pickavance and Dondale 2005. ²¹Pickavance and Dondale 2005. ²²Bowden et al. in press. ²³Bélanger and Hutchinson 1992. ²⁴Paquin and Dupérré 2003. ²⁵Paquin and Dupérré 2006. ²⁶Dondale et al. 1997. ²⁷Dondale 1979 as revised this study. ²⁸Bennett 1999.

* Current (2018) data combine LB and NF together (total 434 species) and are not easily separable. Increase since 2010 for LB and NF combined = 18%.

** National and provincial/territorial species count data in Canadian Endangered Species Conservation Council (2011) are essentially unchanged from those in Paquin et al. 2010 and are not recorded here.

species count could reach 1500 with concerted inventory work in particular habitats, especially forest floors and canopies. Increases in species counts (Table 2) were, as expected, primarily in Linyphiidae (more than 50 species added) but also in groups that had been subject to significant taxonomic revision since 1979, such as Gnaphosidae (about 40 species added) and Lycosidae (20 species). Species counts for other families were relatively unchanged.

Although Bennett's (1999) checklist recorded 38 spider families in the Canadian fauna, six more than reported by Dondale (1979), only two families, Zoridae and Mysmenidae, were truly novel additions through the discovery of populations in BC of species known to be relatively widespread in the western United States. Five other family additions were not novel but the result, rather, of advances in spider systematics and classification: in Dondale (1979) Cybaeidae was classified in Agelenidae, Liocranidae and Corinnidae in Clubionidae, Titanoecidae in Amaurobiidae, and Pimoidae in Linyphiidae. Dondale's (1979) Erigonidae was not included in Bennett (1999) and subsequent lists because of its reclassification as a subfamily of Linyphiidae.

In the 1980s and 1990s, considerable progress was made on Canada's regional spider checklists (Table 3), a reflection of significant spider inventory work in some regions. BC's spider species count more than doubled to 570 (West et al. 1984, 1988) and initial checklists were produced for MB (483 species; Aitchison-Benell and Dondale 1990), QC (549; Bélanger and Hutchinson 1992), and YT (297; Dondale et al. 1997). As with the earlier checklists for BC and NF, the regional checklists of the 1980s and 1990s were still far from complete and major changes would be made through the next couple of decades.

The recent past (Paquin et al. 2010)

Early in the first decade of the 21st Century, DJ Buckle (pers. comm.) began compiling a checklist including the names and basic regional (Canadian provinces and territories and/or Alaska) presence data for all spider species then recorded in Canada and Alaska. The database was subsequently published (Paquin et al. 2010), making widely available for the first time a reasonably comprehensive Canadian national and regional species-level checklist. Thirty-six of the species were known from Alaska but not from anywhere in Canada (one species in each of Clubionidae and Dictynidae, three in Lycosidae, and 31 in Linyphiidae) and one South American species (Sicariidae, see above) was not established in Canada then and has not become so subsequently. Removing those 37 species from consideration, the 2010 checklist recorded 1376 species (Table 3) representing 42 families in one or more of Canada's provinces and territories. Although this species count was not appreciably different from Bennett (1999), four families were newly recorded by Paquin et al. (2010). Three of these families were first Canadian records of non-native species in Amphinectidae (one species, now classified in Desidae), Oonopidae (two species), and Zodariidae (one species). The addition of a fourth family, Miturgidae, was the result of advances in systematics (transfer of two

well-known species from Clubionidae). Among the new introductions, the status of the desid and the oonopids is uncertain. No new records are known since the first (and only) record of the desid in AB in 1991. One of the oonopids has been collected only once, albeit from a natural (but disturbed) outdoor habitat in Victoria BC; the other species is known from a substantial indoor population in Toronto ON (Platnick et al. 2012) and is probably established there. The zodariid is almost certainly an established member of the Canadian fauna; it is now known from relatively natural habitats in southern localities in three provinces (R Bennett and G Blagoev unpubl. data) and appears to be well established in the northern United States (Ramseyer 2016). As in Bennett (1999), family-level species counts in Paquin et al. (2010) showed substantial increases only in Linyphiidae, up about 30 since 1999 (Table 2).

In addition to revising the species names and count data for regions with existing species-level checklists (AB, BC, MB, NF, QC, and YT), a major benefit of Paquin et al. (2010) was the provision of species-level data for those Canadian regions where spider species checklists had not previously existed (Table 3). The low species counts for PE and NU reflected the fact that no serious spider inventory work had yet been done in PE (Bowden et al. in press) and very little in NU (e.g., Leech 1966). The species numbers recorded in 2010 for the remaining “first-time” regions are an indication of substantial spider inventory work in those regions, largely led by CD Dondale and JH Redner of the Canadian National Collection (CNC) but also with significant input of specimens and data from CNC entomologists, Canadian Forest Service researchers, and non-government arachnologists such as DJ Buckle, R Holmberg, and RE Leech.

In the first decade of the 21st Century, Canadian regional spider faunistics work continued to be especially active in BC and QC where, by 2010, both provinces had recorded increases of about 130 species to 700 and 677, respectively (Table 3). In addition, a short burst of intensive spider faunistics work in NF resulted in an increase of more than 150 species for a total of 363 species on the island’s spider checklist (Pickavance and Dondale 2005). Based primarily on large numbers of spider specimens collected during research in the 1990s in localised areas of southern and central BC led by DCA Blades (Blades and Maier 1996), GGE Scudder (unpublished), N Winchester (Copley 2010, Copley and Winchester 2010), and BS Lindgren and J Lemieux (Lindgren et al. 1999), Bennett (2001) and Bennett et al. (2006) updated, respectively, the BC spider species count and the checklist of names and locality data. Family and species-level nomenclature in Bennett et al. (2006) were in agreement with current World Spider Catalog (Platnick 2006) standards, thus simplifying tracking of taxonomic synonyms and other nomenclatural changes in preceding and subsequent BC spider checklists. Two of us (R Bennett and C Copley) and D Copley used locality data in Bennett et al. (2006) to map unsampled or poorly sampled regions and habitats in BC and plan a series of annual field surveys, primarily targeting alpine and subalpine habitats across the province, to address the knowledge gap. With support from the RBCM and a wide range of collaborators, these surveys commenced in 2008 and the first two field seasons resulted in the addition of more than 40 species to the known spider fauna of BC (Bennett et al. 2010), some of which were new records for Canada or even the Nearctic.

In QC, the significant efforts of the team of Paquin and Dupérré (2003, 2006) in the field (as well as in examining specimens in the CNC for overlooked new records) were largely responsible for the increases in the list of spider species known in QC.

The current era and into the future (Canadian Endangered Species Conservation Council 2016 and the rise of BINs)

In 2010, using a draft version of the species list in Paquin et al. (2010) as their baseline, attendees at an ad hoc workshop organised by NatureServe Canada produced an initial consensus-based assessment of the national and regional conservation status of all spider species recorded in Canada (Canadian Endangered Species Conservation Council 2011). In 2013, the Canadian Wildlife Service (Environment Canada) began a comprehensive reanalysis of the conservation status data using NatureServe methodology (Faber-Langendoen et al. 2012) and incorporating all available spider species distribution and abundance data as well as the significant number of novel species records that had accumulated since 2010. The results of the analysis included updated national and regional checklists recording 1399 spider species (Table 3) representing 42 families (data current to 2013; Canadian Endangered Species Conservation Council 2016) and, in 2018, this is the contemporary published resource for species-level faunistic data for Canadian spiders. Family number remained unchanged from 2010 although Zoridae was incorporated into Miturgidae and Anapidae was newly recorded for Canada. Notably, the anapid record, *Comaroma mendocino* (Levi), collected in BC, is one of the rarest of all native spider species in North America (see Lopardo and Coddington 2017). New records of Linyphiidae accounted for two thirds of the relatively minor increases in Canada's family-level spider species counts reported in the 2016 publication (Table 2).

Since 2013, i.e., data incorporated in Canadian Endangered Species Conservation Council (2016), new national records have accumulated rapidly. Seventy-eight new species records have been documented from across Canada (with the majority from BC) resulting in the current Canadian inventory of 1477 spider species in 45 families (Table 1). Linyphiid species account for more than one third (27) of the new records (Table 2) but some families which had not seen much change for several decades also show substantial increases, for example araneid and salticid species counts have increased by 9 and 23 (Table 2), respectively. All three of the new family names in Table 1 are the result of recent classification changes: Eutichuridae was previously classified in Miturgidae while Phrurolithidae and Trachelidae were extracted from Corinnidae.

As with previous checklists, the increased species counts largely reflect the continuation of serious regional spider inventory work. However, molecular data have become increasingly important in Canadian spider faunistics and systematics, and the current Canadian spider species checklist (R Bennett and G Blagoev unpubl. data) is the first to benefit from the use of molecular data. The molecular work, led by the CBG, has combined laboratory work with comprehensive sampling of arthropod specimens in a wide variety of often difficult-to-access and/or previously poorly known habitats in

Canada (deWaard et al. 2017). The RBCM has closely collaborated with the CBG since 2012, resulting in large amounts of novel regional as well as national species-level data (Bennett et al. 2017). In particular, molecular data have been critical in the identification of specimens of described species that previously were unidentifiable (or easily misidentified) because of the lack of good morphology-based diagnostic images or reliably identified voucher specimens (e.g., various linyphiid taxa).

More than 50,000 Canadian spider specimens have been analysed in the course of the barcoding work, representing 92% of the 1477 spider species currently recorded in Canada (Table 1; R Bennett and G Blagoev unpubl. data) and generating 1623 individual Barcode Index Numbers (BINs) (Ratnasingham and Hebert 2013). Unsurprisingly, because nearly 40% of all Canadian spider species are linyphiids, nearly one third of the sequenced specimens are Linyphiidae and those specimens account for nearly 40% of the resultant BINs. BINs in excess of known species-level taxon numbers usually indicate the potential for undescribed species and complexes of cryptic species. This is particularly evident among some smaller families (e.g., Telemididae, Theridiosomatidae, Tetragnathidae, and Trachelidae) which have generated 2–3 times as many distinct BINs as there are named species in the Canadian fauna of those families. Such BIN disparity can be particularly striking for individual species. For example, 18 BINs are associated with a single species, *Tetragnatha versicolor* Walckenaer. For this species, the disparity is not a big surprise: *T. versicolor* is well known for its morphological variability and probable masking of a cryptic species complex (Levi 1981). Similarly, 19 and 25 unique BINs have been generated from specimens of *Evarcha hoyi* (Peckham and Peckham) (Salticidae) and *Grammonota angusta* Dondale (Linyphiidae), respectively.

The accumulation of new provincial/territorial records across Canada has been especially impressive for some jurisdictions (Table 3). Most dramatically, the species count for PE increased by 521% between 2010 and 2018. This was almost entirely because of the combination of data accumulated through CBG's national barcoding project (Blagoev et al. 2016, deWaard et al. 2017) and a "BioBlitz" in 2015 targeting PE's previously poorly known spider fauna (Bowden et al. in press). (BioBlitzes, a relatively new faunistics tool, can be important sources of novel data. For example, in 2014 and 2015 the participation of a team of arachnologists in two BioBlitzes in the small area of Ojibway Park in Windsor ON resulted in the addition of twenty new species records (including six new genus records) to the checklist of Canadian spiders.) The annual intensive surveys of alpine and subalpine habitats in BC begun by the RBCM in 2008 have continued and, along with significant input of specimens and data from a wide variety of collaborators, have resulted in a series of provincial checklists documenting a 25% increase in BC's recorded spider fauna between 2010 and the end of the 2017 field season (Bennett et al. 2012, 2014, 2017, unpubl. data). Spider faunistics in northern Canada benefited from intensive surveys at arctic and subarctic sites by S Loboda and C Buddle (McGill University), R Wisseman (Aquatic Biology Associates, Inc., Corvallis), Perry et al. (2014), the CBG, and others; spider species number increases since 2010 of 71% (124 to 212) and 22% (267 to 325) for LB and NT, respectively, are largely the result of that work. The CBG has also continued to support regional work

led by others, such as in BC and PE. This has been mutually beneficial, helping the CBG to complete its library of BINs for Canadian spider taxa and the provinces and territories to achieve a more complete understanding of their regional spider faunas.

Summary (and some predictions for the future)

The rate of increase in Canada's spider species count shows little sign of slowing down. In 2018 the count is well beyond the approximately 1400 predicted by Dondale (1979) and is rapidly closing in on Bennett's (1999) estimate of about 1500. For example, consider the case of BC, which has a longer and more consistent history of spider faunistics research than do other regions of Canada (Table 3) and is the nation's most ecologically diverse province (Morrison and Turner 1994). On average, more than 20 species (primarily linyphiids) have been added annually to the BC regional checklist since 2006 (many of the new records are the result of the RBCM's on-going collaboration with the CBG) and more than 70 of the additions to the BC checklist are of species not previously recorded in Canada and, in some instances, the Nearctic (Bennett et al. 2016, 2017). Although the inventory work conducted annually since 2008 by RBCM researchers and their colleagues has resulted in a major increase in the area of BC surveyed for spiders (see fig. 1 in Bennett et al. 2017), habitats in much of the province remain unsurveyed, especially in the province's Boreal Cordillera, Taiga and Boreal Plains, northern Montane Cordillera, and central Pacific Maritime ecozones. Nearly two thirds of all spider species recorded in Canada occur in BC (Table 3). The Nearctic region is home to close to 3800 spider species (Cushing 2018), nearly one quarter of which have been recorded in BC. Clearly, BC is an important region for Nearctic spider diversity and, assuming the RBCM-led work continues, the BC spider species count eventually is likely to exceed 1000, as first predicted by Bennett et al. (2012). Some proportion of those species will be novel Canadian or even Nearctic records. Although other regions of Canada lack BC's complex ecological diversity, with the exception of PE, all have vast amounts of habitat in which the spider fauna has never been surveyed (or only poorly so). Canada's boreal forest, southern hardwood forest, alpine/subalpine, and subarctic tundra habitats are excellent candidates for the discovery of novel regional and national species records given sufficient search effort. As well, provinces sharing borders and particular terrestrial habitats with the United States (e.g., BC's dry southern interior valleys; the southern grasslands of AB, SK, and MB; and southern ON's Carolinian forests and tallgrass prairies) have been the source of novel national species records historically (usually northern range extensions of southern species) and likely will continue to be so in a warming climate.

Finally, DNA barcoding has proven to be an effective complement to classic morphological techniques for identifying spiders and contributing to the advancement of Canadian spider faunistics (Barrett and Hebert 2005, Robinson et al. 2009, Blagoev et al. 2013, 2016, Blagoev and Dondale 2014). At this time the CBG's reference library,

BOLD (Ratnasingham and Hebert 2007), contains DNA barcodes for 92% of Canada's 1477 known spider species. Many BINs, appear to reflect cryptic species complexes within well-known taxa (e.g., the example provided by *Tetragnatha versicolor*) but nearly 60 BINs are associated with Canadian taxa that remain unidentified for a variety of reasons. These have interim, temporary names in BOLD and eventually may be matched to named taxa pending sufficient laboratory detective work or future sequence matching. At least 25 of the BINs, however, are associated with species that are clearly new to science – unnamed and undescribed but morphologically easily discernible. For example, during the period 2014 to 2017 many hundreds of specimens of an unidentifiable but morphologically distinctive species of *Perro* Tanasevitch (Linyphiidae) were collected at alpine localities in northern BC and southern YT. DNA barcoding and associated taxonomic detective work at the CBG confirmed that this taxon, although morphologically distinctive and common and abundant in relevant habitat, is a Beringian species new to science. Another example is provided by the first Nearctic records of the Palaearctic genus *Mughiphantes* Saaristo and Tanasevitch (Linyphiidae), an undescribed species initially revealed in 2009 by barcoding of originally unidentifiable specimens from Churchill MB (Blagoev et al. 2013). Subsequent barcoding of further unidentified specimens from other localities has demonstrated that the species is relatively common and widespread in subarctic habitats in AB, BC, LB, MB, NF, QC, and YT.

Future additions to the checklist of Canadian spiders will likely follow the historical precedent shown in Table 2: dominance by linyphiids augmented by new data from difficult groups (e.g., salticids) or emerging from formal taxonomic revisions (e.g., such as occurred with gnaphosids and lycosids between 1979 and 1999). The most recent published estimate for the “actual total” number of spider species in the Canadian fauna (Paquin et al. 2010) is approximately 1720. This is probably a reasonable estimate, given the continuing accumulation of substantial numbers of named species to the checklist of the Canadian spider fauna and of species new to science and awaiting description prior to their addition to the national checklist. However, if most of the excess BINs reflect real but cryptic species, it will not be surprising to see the species count approach or exceed 1800. Tune in again in 20 or 30 years...

Acknowledgements

We thank the many people unnamed elsewhere in this paper who have aided us directly or have otherwise made significant contributions to the advancement of Canadian spider faunistics. Darren Copley, in particular, is a critical member of the BC spider team: both in the field and for determinations back in the lab. Among others: Kyron Basu, Bruce Bennett, James Bergdahl, Bob Brett, Syd Cannings, Paul Catling, Suzanne Carrière, Rod Crawford, Jakob Dulisse, Crystal Ernst, Rémi Hébert, Jennifer Heron, Dan Johnson, Bronwen Lewis, Ron Long, Norma Kerby, Rose and Brian Klinkenberg, Marty Kranabetter, Dave Langor, Max Larrivée, Ron Long, Andy MacKinnon, John McLean, Wayne Maddison, Samantha Magnus, Tom Mason, Sean McCann, André-Philippe Picard, Jaime Pinzon, Robert Puls, Leah Ramsey, Kendra Schotzko, Cath-

erine Scott, Janean Sharkey, John Swann, Melissa Todd, Susan Wise-Eagle, Ken White, Charlene Wood, the folks in the Flathead Wild coalition, and our RBCM field work colleagues Richard Hebda, Ken Marr, and Erica Wheeler.

The Royal BC Museum has provided significant financial support for the necessary field work we have been undertaking in the province. Financial support for the International Barcode of Life project was provided by the Ontario Ministry of Research and Innovation, Genome Canada, and the Ontario Genomics Institute. We also thank all our colleagues at the CBG for making the Barcode of Life project work successfully. We are grateful to Parks Canada and Provincial and Territorial Parks staff for supporting collection programs in Canada's national and regional parks.

Finally, we wish to extend special thanks and appreciation to Charlie Dondale and Don Buckle. Charlie led the way for years, putting Canada on the arachnological map of the world, mentoring many past and present arachnologists, and continuing to be active and interested in Canadian spider taxonomy and faunistics decades after his retirement. Don has been the “go-to” person who provided much of the ID work on Canadian spiders for years after Charlie's retirement. Don remains very active as well, and both (perhaps unwittingly) are icons of arachnological socialism (the free, unfettered, and unconditional sharing of arachnological data), a philosophy without which much of what we do would be far more difficult than it is.

References

- Aitchison-Benell CW, Dondale CD (1990) A checklist of Manitoba spiders (Araneae) with notes on geographic relationships. *Le Naturaliste Canadien* 117: 215–237.
- Barrett RDH, Hebert PDN (2005) Identifying spiders through DNA barcoding. *Canadian Journal of Zoology* 83: 481–491. <https://doi.org/10.1139/z05-024>
- Bélanger G, Hutchinson R (1992) Liste annotée des araignées (Araneae) du Québec. *Pirata* 1: 2–119.
- Bennett RG (1999) Canadian spider diversity and systematics. *Newsletter of the Biological Survey of Canada (Terrestrial Arthropods)* 18: 16–27.
- Bennett RG (2001) Spiders (Araneae) and araneology in British Columbia. *Journal of the Entomological Society of British Columbia* 98: 85–92.
- Bennett RG, Blades D, Blagoev G, Buckle D, Copley C, Copley D, Dondale C, West R (2017) Checklist of the spiders of British Columbia. In: Klinkenberg B (Ed.) *E-Fauna BC: Electronic Atlas of the Fauna of British Columbia*. University of British Columbia, Vancouver. <http://www.efauna.bc.ca> [Accessed 22.III.2018]
- Bennett RG, Blades D, Buckle D, Copley C, Copley D, Dondale CD, West RC (2012) Checklist of the spiders of British Columbia. In: Klinkenberg B (Ed.) *E-Fauna BC: Electronic Atlas of the Fauna of British Columbia*. University of British Columbia, Vancouver. <https://web.archive.org/web/20121001032632/http://www.geog.ubc.ca:80/> [Accessed 22.III.2018]
- Bennett RG, Blades D, Buckle D, Copley C, Copley D, Dondale CD, West R (2014) Checklist of the spiders of British Columbia [online database] In: Klinkenberg B (Ed.) *E-Fauna BC: Electronic Atlas of the Fauna of British Columbia*. University of British Columbia, Vancouver. <https://web.archive.org/web/20140725013518/http://efauna.bc.ca:80/> [Accessed 22.III.2018]

- Bennett RG, Blades D, Dondale CD, Buckle DJ, West R (2006) The spiders of British Columbia [online database] In: Klinkenberg B (Ed.) E-Fauna BC: Electronic Atlas of the Fauna of British Columbia. University of British Columbia, Vancouver. <https://web.archive.org/web/20061005030402/http://efauna.bc.ca:80/> [Accessed 22.III.2018]
- Bennett RG, Blades D, Dondale CD, Buckle DJ, West RC (2010) The spiders of British Columbia [online database] In: Klinkenberg B (Ed.) E-Fauna BC: Electronic Atlas of the Fauna of British Columbia. University of British Columbia, Vancouver. <https://web.archive.org/web/20110626061300/http://www.geog.ubc.ca:80/> [Accessed 22.III.2018]
- Bennett RG, Copley C, Copley D (2016) Documenting diversity: surveying British Columbia's spider fauna. 20th International Congress of Arachnology. Denver Museum of Nature Science Reports 3: 49. [abstract]
- Blades DCA, Maier CW (1996) A survey of grassland and montane arthropods collected in the southern Okanagan region of British Columbia. *Journal of the Entomological Society of British Columbia* 93: 49–74.
- Blagoev GA, deWaard JR, Ratnasingham S, deWaard SL, Lu L, Robertson J, Telfer AC, Hebert PD (2016) Untangling taxonomy: a DNA barcode reference library for Canadian spiders. *Molecular Ecology Resources* 16: 325–341. <https://doi.org/10.1111/1755-099812444>
- Blagoev GA, Dondale CD (2014) A new species of *Alopecosa* (Araneae: Lycosidae) from Canada: a morphological description supported by DNA barcoding of 19 congeners. *Zootaxa*, 3894: 152–160. <http://dx.doi.org/10.11646/zootaxa.3894.1.12>
- Blagoev GA, Nikolova NI, Sobel CN, Hebert PD, Adamowicz SJ (2013) Spiders (Araneae) of Churchill, Manitoba: DNA barcodes and morphology reveal high species diversity and new Canadian records. *BMC Ecology* 13: 44. <https://doi.org/10.1186/1472-6785-13-44>
- Bowden JJ, Knysh KM, Blagoev GA, Bennett R, Arsenault MA, Harding CF, Harding RW, Curley R (in press) The spiders of Prince Edward Island: citizen scientists contribute to faunistics. *Canadian Field Naturalist*.
- Bragg PD, Leech RE (1972) Additional records of spiders (Araneida) and harvestmen (Phalangida) for British Columbia. *Journal of the Entomological Society of British Columbia* 69: 67–71.
- Canadian Endangered Species Conservation Council (2011) Wild Species 2010: The general status of species in Canada. National General Status Working Group. <http://www.registrel-ep-sararegistry.gc.ca/> [Accessed 22.III.2018]
- Canadian Endangered Species Conservation Council (2016) Wild Species 2015: The general status of species in Canada. National General Status Working Group. <http://www.registrel-ep-sararegistry.gc.ca/> [Accessed 22.III.2018]
- Coddington JA, Levi HW (1991) Systematics and evolution of spiders (Araneae). *Annual Review of Ecology and Systematics* 22: 565–592. <https://doi.org/10.1146/annurev.es.22.110191.003025>
- Copley C (2010) Spider assemblages in the Carmanah Valley, Vancouver Island, Canada. LAP Lambert Academic Publishing, Saarbrücken, Germany, 77 pp.
- Copley C, Winchester N (2010) Effect of disturbance and distance from a riparian corridor on spiders in a temperate rainforest. *Canadian Journal of Forest Research* 40: 904–916. <https://doi.org/10.1139/X10-043>

- Cushing PE (2018) Introduction. In: Ubick D, Paquin P, Cushing PE, Roth V (Eds) Spiders of North America: an identification manual, 2nd edition. American Arachnological Society, Keene, New Hampshire, 1–16.
- deWaard JR, Levesque-Beaudin V, deWaard SL, Ivanova NV, McKeown JTA, Miskie R, Naik S, Perez K, Ratnasingham S, Sobel CN, Sones JE, Steinke C, Telfer AC, Young AD, Young MR, Zakharov EV, Hebert PD (2017) Expedited assessment of terrestrial arthropod diversity by coupling Malaise traps with DNA barcoding. bioRxiv. <http://dx.doi.org/10.1101/192732>
- Dondale CD (1979) Araneae. In: Danks HV (Ed.) Canada and its insect fauna: an overview. Memoirs of the Entomological Society of Canada No. 108, 247–250. <https://doi.org/10.4039/entm111108247-1>
- Dondale CD, Redner JH, Marusik YM (1997) Spiders (Araneae) of the Yukon Territory. In: Danks HV, Downes JA (Eds) Insects of the Yukon. Biological Survey of Canada Monograph Series No 2. Biological Survey of Canada (Terrestrial Arthropods), Ottawa, Ontario, 73–113.
- Emerton JH (1920) Catalogue of the spiders of Canada known to the year 1919. Transactions of the Royal Canadian Institute, Toronto 12: 309–338.
- Faber-Langendoen D, Nichols J, Master L, Snow K, Tomaino A, Bittman R, Hammerson G, Heidel B, Ramsay L, Teucher A, Young B (2012) NatureServe conservation status assessments: methodology for assigning ranks. NatureServe, Arlington, Virginia. http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusmethodology_jun12pdf [Accessed 22.III.2015]
- Hackman W (1954) The spiders of Newfoundland. Acta Zoologica Fennica 79: 1–99.
- Langor DW (2019) The diversity of terrestrial arthropods in Canada. In: Langor DW, Sheffield CS (Eds) The Biota of Canada – A Biodiversity Assessment. Part 1: The Terrestrial Arthropods. ZooKeys 819: 9–40. <https://doi.org/10.3897/zookeys.819.31947>
- Leech RE (1966) The spiders (Araneida) of Hazen Camp 81°49'N, 71°18'W. Quaestiones Entomologicae 2: 153–212.
- Levi HW (1981) The American orb-weaver genera *Dolichognatha* and *Tetragnatha* north of Mexico (Araneae: Araneidae, Tetragnathinae). Bulletin of the Museum of Comparative Zoology 149: 271–318.
- Lindgren BS, Lemieux JP, Steventon D (1999) Effects of silviculture systems on arthropod community structure: contrasting clearcut and patch retention harvests in high elevation forest. British Columbia Forest Service, Extension Note #37, Forest Sciences, Prince Rupert Forest Region, Smithers, British Columbia, 4 pp.
- Lopardo L, Coddington JA (2017) Anapidae. In: Ubick D, Paquin P, Cushing PE, Roth V (Eds) Spiders of North America: an identification manual, 2nd edition. American Arachnological Society, Keene, New Hampshire, 73–74.
- Morrison KE, Turner AM (1994) Protected areas in British Columbia: maintaining natural diversity. In: Harding LE, McCullum E (Eds) Biodiversity in British Columbia: Our Changing Environment. Canadian Wildlife Service, Pacific and Yukon Region, Vancouver, British Columbia, 355–373.

- Paquin P, Buckle DJ, Dupérré N, Dondale CD (2010) Checklist of the spiders (Araneae) of Canada and Alaska. *Zootaxa* 2461: 1–170.
- Paquin P, Dupérré N (2003) Guide d'identification des araignées du Québec. Fabriques, Supplément 11: 1–251.
- Paquin P, Dupérré N (2006) The spiders of Québec: update, additions and corrections. *Zootaxa* 1133: 1–37.
- Perry RC, Pickavance JR, Pardy S (2014) Spiders of the southern taiga biome of Labrador, Canada. *Canadian Field-Naturalist* 128: 363–376. <https://doi.org/10.22621/cfn.v128i4.1630>
- Pickavance JR, Dondale CD (2005) An annotated checklist of the spiders of Newfoundland. *Canadian Field-Naturalist* 119: 254–275. <https://doi.org/10.22621/cfn.v119i2.114>
- Platnick NI (2006) The world spider catalog, version 6.5. American Museum of Natural History, New York, New York. https://wscnmbch/resources/archive/catalog_65/INTRO2html [Accessed 22.III.2018]
- Platnick NI, Berniker L, Kranz-Baltensperger Y (2012) The goblin spider genus *Ischnothyreus* (Araneae, Oonopidae) in the New World. *American Museum Novitates* 3759: 1–32. <https://doi.org/10.1206/3759.2>
- Ramseyer, L (2016) First records of *Zodarion rubidum* (Zodariidae) in Washington, USA. <http://pineconespiders.blogspot.ca/2016/07/first-records-of-zodarion-rubidum.html> [Accessed 22.III.2018]
- Ratnasingham S, Hebert PD (2007) BOLD: The barcode of life data system (www.barcodinglife.org). *Molecular Ecology Notes* 7: 355–364.
- Ratnasingham S, Hebert PD (2013) A DNA-based registry for all animal species: the barcode index number (BIN) system. *PLoS ONE* 8: e66213.
- Robinson E, Blagoev G, Hebert PD, Adamowicz S (2009) Prospects for using DNA barcoding to identify spiders in species-rich genera. *ZooKeys* 16: 27–46. <https://doi.org/10.3897/zookeys.16.239>
- Thorne E (1967) Preliminary distributional list of the spiders of British Columbia. Report of the Provincial Museum of Natural History and Anthropology of British Columbia, Victoria, British Columbia, 17 pp.
- Ubick D, Paquin P, Cushing PE, Roth V (2017) Spiders of North America: an identification manual (2nd edn). American Arachnological Society, Keene, New Hampshire, 425 pp.
- West R, Dondale CD, Ring RA (1984) A revised checklist of the spiders (Araneae) of British Columbia. *Journal of the Entomological Society of British Columbia* 81: 80–98.
- West R, Dondale CD, Ring RA (1988) Additions to the revised checklist of the spiders (Araneae) of British Columbia. *Journal of the Entomological Society of British Columbia* 85: 77–86.
- Wheeler WC, Coddington JA, Crowley LM, Dimitrov D, Goloboff PA, Griswold CE, Hormiga G, Prendini L, Ramírez MJ, Sierwald P, Almeida-Silva LM, Álvarez-Padilla F, Arnedo MA, Benavides LR, Benjamin SP, Bond JE, Grismado CJ, Hasan E, Hedin M, Izquierdo MA, Labarque FM, Ledford J, Lopardo L, Maddison WP, Miller JA, Piacentini LN, Platnick NI, Polotow D, Silva-Dávila D, Scharff N, Szűts T, Ubick D, Vink C, Wood HM, Zhang JX (2017) The spider tree of life: phylogeny of Araneae based on target-gene analyses from an extensive taxon sampling. *Cladistics* 33: 576–616.
- World Spider Catalog (2018) World spider catalog version 19.0. Natural History Museum Bern, Switzerland. <http://wsc.nmbe.ch> [Accessed 28.II.2018]