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COMMUNICATION

Spider taxonomy for an advanced China

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Abstract This paper summarizes the advances and challenges in spider taxonomy of China. A table comparing the number of valid genera and species in China, Europe and the world is provided. To date, the Chinese spider fauna is represented by 5,084 species, under 809 genera in 69 spider families. An "All Species Inventory" of spiders in Xishuangbanna Tropical Botanical Garden provides an example of China's spider species richness, with more than 782 species recorded within a small area. Intensified research in recent years has grown the national catalog of Chinese spiders from 1,050 species in 1983 to 5,084 species today. There are reasons to believe that spider species richness in China will far exceed this grand total. With enhanced support and investment in spider taxonomic research, many more new species will be discovered and described in China.

Key words Europe, families, genera, species, worldwide.

The study of spider taxonomy in China has spanned over the last 140 years. Early studies of Chinese spiders were initiated in the late 18th century and followed through in the first half of the 20th century mainly by foreign arachnologists such as Simon (1880), Pickard-Cambridge (1885), Pocock (1901), Chamberlin (1924), Fox (1935, 1936, 1937a, b, 1938), Saitō (1936), and Schenkel (1936, 1944, 1953, 1963). In 1935, Professor Fengzhen Wang recorded 566 spider species of China based on published literature. From 1936 to 1946, he visited natural history museums in Berlin, Munich, Vienna, Basel and Paris to examine spider specimens. He sorted out species with dubious placements, and synonymized some of them, thus consolidating the Chinese species list with 438 valid species, spread over 130 genera in 30 families (Li, 2004). Wang and Zhu (1963) supplemented the list with new discoveries in China from 1946 to 1963, resulting in a total of 521 species and 15 subspecies, grouped under 149 genera in 34 families. Zhu (1983) published a revised Chinese spider catalog, which recorded 1,050 species and 23 subspecies under 46 families. Chen *et al.* (1996) established a web database and interactive information service system for Chinese spiders, recording 2,159 species under 413 genera in 56 families. Song *et al.* (1999) described 2,361 species under 450 genera in 56 spider families in China. Li and Lin (2016) summarized the results of domestic spider cataloguing, culminating in a record of 4,282 species under 735 genera in 69 spider families. The inventory has since grown. Currently, 5,084 species under 809 genera in 69 spider families are known from China (Table 1).

According to Platnick (2000), there were 37,296 species under 3,449 genera in 108 spider families worldwide in the year of 2000. Now the global catalog has ballooned to 48,479 species under 4,159 genera in 120 families (WSC, 2020), showing an average rate of increase of 558 species per year. The taxonomy of Chinese spiders in China has developed exponentially in recent years. In 1999, 2,361 species under 450 genera in 56 families were recorded from China (Song *et al.*, 1999). By 2020, the inventory has reached 5,084 species under 809 genera in 69 families, representing a jump of 2,720 species, 360 genera, and 13 families, with an average annual rate of increase of 136 species (including new species and new records, while excluding synonymized and misidentified species). Such rapid advances in documenting spider biodiversity in China has not only validated the massive national investment in scientific research, but also helped to sustain taxonomic investigations of our biodiversity hotspots. For example, we have been conducting an "All Species Inventory" of the spiders

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in Xishuangbanna Tropical Botanical Garden (XTBG) over the last 15 years. Our survey has shown that even within the narrow confines of XTBG and its adjacent area, there are as many as 782 species of spiders, spanning over 305 genera in 46 families, of which about 400 are new to science. Meanwhile, more spiders are being discovered and the figure of XTBG spider species richness may hit 1,000 species. As a comparison, the number of spider species in the United Kingdom, where the spider taxonomy has been well studied, stands at a mere 684 (Nentwig *et al.*, 2020).

With a history of more than 250 years, the study of spider taxonomy in Europe has resulted in a record of 63 families, 720 genera and 5,224 species of spiders (Nentwig *et al.*, 2020). Both Europe and China are located at almost the same latitude in Eurasia. The compositions of their spider fauna are very similar. With 57 families in common, the total spider families in China represents 81% of that recorded in Europe. In terms of geographic sizes, Europe and China are roughly similar in areas. At present, the number of spider species in China seems comparable to that in Europe (Table 1). However, the eventual total number of Chinese spider species may far exceed that of Europe, even by two to three folds. There are two reasons for this. First, southwestern China (the Himalayan Mountains, the Hengduan Mountains and the Yunnan-Guizhou Plateau) has been the center of diversification for several spider groups (Zhao & Li, 2018, Li *et al.*, 2020). Southwestern China lied to the eastern margin of ancient Tethys (Hou *et al.*, 2011; Hou & Li, 2018). The withdrawal of the Tethys began at southwestern China and the Tethyan sea-land changes caused the formation of extratropical biodiversity hotspots in China, which was accelerated during the Oligocene–Miocene era. In contrast to tropical areas, species richness in extratropical hotspots does not depend on the variety of niches or habitats, but the emergence of new, isolated habitats. Second, the European and Asian continents have experienced different glacial histories. Many European species expanded in the post-Last Glacial Maximum Quaternary period, while in southwestern China, species were established before the Last Glacial Maximum. The high-latitude regions of Europe were covered by heavy ice during most periods of the Pleistocene, but glaciations in southwestern China were restricted to relatively high altitudes and did not affect the lower slopes or valleys, leading to the "sky island" distribution pattern (Lei, 2012).

Meng *et al.* (2008) studied the biogeographical patterns of Chinese spiders based on a parsimony analysis of endemicity, and the result showed that Chinese spiders are distributed over five regions: the Tibetan Plateau, and the Central Northern, Eastern Northern, Western Northern (excluding Tibetan Plateau), and Southern regions. This pattern echoes the division of geographical provinces by the orogenic belt multi-island model, but the boundaries of spider distribution are shifted south relative to the boundaries of the geographical provinces. Studies have shown that the distribution pattern changed after the orogenic period. The process of change has created new opportunities for proliferation, extinction, invasion, and species formation.

Table 1. Valid spider genera and species of worldwide, Europe and China (updated in March 16, 2020).

	Worldwide		Europe		China			Worldwide		Europe		China	
	Genera	Species	Genera	Species	Genera	Species		Genera	Species	Genera	Species	Genera	Species
Actinopodidae	3	73	-	-	-	-	Corinnidae	68	787	4	6	6	20
Agelenidae	83	1327	20	236	35	445	Ctenidae	48	519	2	2	4	10
Amaurobiidae	49	274	4	42	2	12	Ctenizidae	3	52	2	5	-	-
Ammoxenidae	4	18	-	-	-	-	Cyatholipidae	23	58	-	-	-	-
Anapidae	58	233	3	5	7	12	Cybaeidae	19	264	7	26	1	6
Antrodiaetidae	4	37	-	-	-	-	Cycloctenidae	8	80			-	-
Anyphaenidae	56	572	1	6	1	6	Cyrtaucheniidae	11	118	2	17	-	-
Araneidae	176	3078	1	112	50	402	Deinopidae	3	67	-	-	1	4
Archaeidae	5	90			-	-	Desidae	60	297	1	1	2	2
Arkyidae	2	38	-	-	-	-	Dictynidae	52	470	18	68	13	62
Atracidae	3	35	-	-	-	-	Diguetidae	2	15	-	-	-	-
Atypidae	3	54	1	3	2	17	Dipluridae	26	201	-	-	1	1
Austrochilidae	3	10	-	-	-	-	Drymusidae	2	17	-	-	-	-
Barychelidae	42	295	-	-	-	-	Dysderidae	25	574	23	406	1	1
Caponiidae	18	119	-	-	1	1	Eresidae	9	99	5	31	2	3
Cheiracanthiidae	12	353	2	36	1	42	Euctenizidae	7	76	-	-	-	-
Cithaeronidae	2	8	1	2	-	-	Filistatidae	19	182	4	16	5	20
Clubionidae	16	639	2	51	5	153	Gallieniellidae	10	68	-	-	-	-

Table 1 (continued)

	Worldwide		Europe		China			Worldwide		Europe		China	
	Genera	Species	Genera	Species	Genera	Species		Genera	Species	Genera	Species	Genera	Species
Gnaphosidae	159	2539	51	579	35	211	Philodromidae	31	538	7	111	5	58
Gradungulidae	7	16	-	-	-	-	Pholcidae	94	1736	14	59	16	227
Hahniidae	23	351	7	31	5	48	Phrurolithidae	13	228	4	13	3	85
Halonoproctidae	6	94	1	4	4	28	Physoglenidae	13	72			-	-
Hersiliidae	16	182	3	6	2	10	Phyxelididae	14	64	1	1	-	-
Hexathelidae	7	45	-	-	-	-	Pimoidae	4	45	1	4	3	16
Hexurellidae	1	4	-	-	-	-	Pisauridae	51	356	3	9	11	42
Homalonychidae	1	3	-	-	-	-	Plectreuridae	2	31	-	-	-	-
Huttoniidae	1	1	-	-	-	-	Porrhothelidae	1	5	-	-	-	-
Hypochilidae	2	12	-	-	1	2	Psechridae	2	61	-	-	2	18
Idiopidae	22	409	1	1	-	-	Psilodercidae	11	165	-	-	6	40
Lamponidae	23	192	-	-	-	-	Salticidae	646	6183	67	451	118	526
Leptonetidae	21	352	8	71	3	119	Scytodidae	5	248	1	12	3	21
Linyphiidae	613	4624	221	1357	162	403	Segestriidae	4	133	2	18	2	7
Liocranidae	32	283	12	62	7	29	Selenopidae	9	260	1	2	2	4
Liphistiidae	8	135	-	-	5	37	Senoculidae	1	31	-	-	-	-
Lycosidae	125	2439	34	355	28	312	Sicariidae	3	169	1	2	1	3
Macrothelidae	1	33	1	3	1	16	Sparassidae	89	1262	8	40	12	160
Malkaridae	11	46	-	-	-	-	Stenochilidae	2	13	-	-	1	1
Mecicobothriidae	1	2	-	-	-	-	Stiphidiidae	20	125	-	-	-	-
Mecysmaucheniidae	7	25	-	-	-	-	Symphytognathidae	8	74	1	1	4	19
Megadictynidae	2	2	-	-	-	-	Synaphridae	3	13	2	5	-	-
Megahexuridae	1	1	-	-	-	-	Synotaxidae	1	11	-	-	-	-
Microstigmatidae	8	24	-	-	-	-	Telemidae	14	97	1	1	3	51
Migidae	11	102	-	-	-	-	Tetrablemmidae	27	143	-	-	8	15
Mimetidae	12	154	3	10	3	22	Tetragnathidae	48	978	6	38	19	142
Miturgidae	29	137	2	12	5	9	Theraphosidae	147	1000	3	10	4	10
Myrmecicultoridae	1	1	-	-	-	-	Theridiidae	124	2516	48	260	56	402
Mysmenidae	14	137	3	4	8	40	Theridiosomatidae	19	128	1	1	10	28
Nemesiidae	45	431	4	86	3	18	Thomisidae	170	2149	20	212	51	304
Nesticidae	16	278	8	55	6	56	Titanoecidae	5	54	3	19	4	12
Nicodamidae	7	27	-	-	-	-	Toxopidae	14	82	-	-	-	-
Ochyroceratidae	10	166	1	1	2	15	Trachelidae	19	244	4	10	6	30
Oecobiidae	6	119	2	16	2	9	Trechaleidae	17	131	-	-	-	-
Oonopidae	113	1846	19	52	14	84	Trochanteriidae	21	171	-	-	1	12
Orsolobidae	30	188	-	-	-	-	Trogloraptoridae	1	1	-	-	-	-
Oxyopidae	9	453	2	15	4	58	Ududidae	4	15	-	-	-	-
Pacullidae	4	38	-	-	1	1	Uloboridae	19	286	4	9	6	49
Palpimanidae	18	152	2	10	1	1	Viridasiidae	2	9	-	-	-	-
Paratropididae	5	17	-	-	-	-	Xenoctenidae	4	33	-	-	-	-
Penestomidae	1	9	-	-	-	-	Zodariidae	86	1168	9	135	8	50
Periegopidae	1	3	-	-	-	-	Zoropsidae	27	182	2	9	2	5
Total	4159	48479	702	5233	809	5084							

Despite the progress achieved in Chinese spider taxonomy in recent years, research in this area is still plagued by two chronic issues. First, the identification of problematic species in China. Many Chinese species were first described by pioneer Western arachnologists purely in text, without any accompanying illustrations. Although we have recently resolved the identity of some problematic species by examining the type specimens (Tu *et al.*, 2005, Peng & Li, 2003), there are still considerable species requiring further investigation and revision. Second, the identification of problematic species in countries neighboring China. More research is required on some of those spiders initially described from Myanmar (Thorell, 1895), Pakistan (Dyal, 1935), and India (Tikader, 1971), because the range of such species extends across the border to adjacent China. Only by strengthening the research on spiders in neighboring countries will it be possible for the taxonomy of spiders in China be fully and accurately resolved.

Documenting the spectacular species richness and diversity of the spider fauna in China presents to the arachnologists both a heavy responsibility and an exciting intellectual challenge. We are confident that with timely andenhanced support and investment for such research, even greater strides can be achieved in advancing spider inventory and taxonomy in China.

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