# Taxonomic Composition and Spatiotemporal Patterns of Crabronidae (Hymenoptera) in Southwestern China

## Supplementary material

**Table S1.** Tribe level observations of family Crabronidae based on records, species, and number of unique localities in southwestern China.

| Subfamily | Tribe | No. of records | No. of species | No. of genera | No. of unique localities |
|---|---|---|---|---|---|
| Bembicinae | Alyssontini | 9 | 7 | 1 | 6 |
| Bembicinae | Bembicini | 2 | 1 | 1 | 2 |
| Bembicinae | Nyssonini | 2 | 1 | 1 | 2 |
| Crabroninae | Crabronini | 81 | 30 | 7 | 60 |
| Crabroninae | Larrini | 10 | 5 | 2 | 10 |
| Crabroninae | Miscophini | 29 | 14 | 2 | 18 |
| Crabroninae | Oxybelini | 4 | 3 | 1 | 4 |
| Crabroninae | Trypoxylini | 50 | 23 | 2 | 29 |
| Pemphredoninae | Pemphredonini | 125 | 48 | 7 | 102 |
| Pemphredoninae | Psenini | 51 | 22 | 5 | 44 |
| Philanthinae | Cercerini | 10 | 6 | 1 | 10 |

**Table S2.** Occurrence records of family Crabronidae by genus in southwestern China.

| Subfamily | Tribe | Genus | Records No. | Species | Earliest recorded year | Latest recorded year | Species (%) |
|---|---|---|---|---|---|---|---|
| Crabroninae | Trypoxylini | *Trypoxylon* | 47 | 22 | 1981 | 2021 | 13.8 |
| Crabroninae | Crabronini | *Crossocerus* | 30 | 13 | 1955 | 2025 | 8.1 |
| Pemphredoninae | Pemphredonini | *Carinostigmus* | 43 | 11 | 1981 | 2018 | 6.9 |
| Pemphredoninae | Pemphredonini | *Stigmus* | 27 | 11 | 1981 | 2023 | 6.9 |
| Pemphredoninae | Pemphredonini | *Passaloecus* | 20 | 10 | 1976 | 2025 | 6.2 |
| Pemphredoninae | Psenini | *Psen* | 17 | 10 | 1957 | 2021 | 6.2 |
| Crabroninae | Miscophini | *Nitela* | 18 | 9 | 2005 | 2021 | 5.6 |
| Bembicinae | Alyssontini | *Alysson* | 9 | 7 | 1957 | 1993 | 4.4 |
| Philanthinae | Cercerini | *Cerceris* | 10 | 6 | 1945 | 2008 | 3.8 |
| Pemphredoninae | Psenini | *Psenulus* | 18 | 5 | 1909 | 2021 | 3.1 |
| Pemphredoninae | Pemphredonini | *Polemistus* | 15 | 5 | 1981 | 2016 | 3.1 |
| Crabroninae | Crabronini | *Rhopalum* | 14 | 5 | 1957 | 2025 | 3.1 |
| Crabroninae | Miscophini | *Lyroda* | 11 | 5 | 2005 | 2020 | 3.1 |
| Pemphredoninae | Pemphredonini | *Spilomena* | 8 | 5 | 1981 | 2009 | 3.1 |
| Crabroninae | Crabronini | *Dasyproctus* | 26 | 3 | 2003 | 2007 | 1.9 |
| Pemphredoninae | Psenini | *Mimumesa* | 9 | 3 | 1956 | 2020 | 1.9 |
| Pemphredoninae | Pemphredonini | *Pemphredon* | 7 | 3 | 1956 | 2025 | 1.9 |
| Crabroninae | Larrini | *Liris* | 6 | 3 | 1956 | 2006 | 1.9 |
| Pemphredoninae | Psenini | *Mimesa* | 6 | 3 | 1976 | 2025 | 1.9 |
| Pemphredoninae | Pemphredonini | *Tzustigmus* | 5 | 3 | 1981 | 2006 | 1.9 |
| Crabroninae | Crabronini | *Ectemnius* | 4 | 3 | 1992 | 1995 | 1.9 |
| Crabroninae | Crabronini | *Encopognathus* | 4 | 3 | 2005 | 2007 | 1.9 |
| Crabroninae | Oxybelini | *Oxybelus* | 4 | 3 | 1992 | 2007 | 1.9 |
| Crabroninae | Larrini | *Tachytes* | 4 | 2 | 1956 | 2003 | 1.2 |
| Crabroninae | Crabronini | *Entomognathus* | 2 | 2 | 1958 | 1958 | 1.2 |
| Crabroninae | Trypoxylini | *Pison* | 3 | 1 | 2005 | 2005 | 0.6 |
| Bembicinae | Nyssonini | *Brachystegus* | 2 | 1 | 1956 | 1957 | 0.6 |
| Bembicinae | Bembicini | *Lestiphorus* | 2 | 1 | 1957 | 1957 | 0.6 |
| Crabroninae | Crabronini | *Lestica* | 1 | 1 | 2006 | 2006 | 0.6 |
| Pemphredoninae | Psenini | *Odontopsen* | 1 | 1 | 2007 | 2007 | 0.6 |

**Table S3.** Exact regional combinations represented by the 160 species. The table reports the number of regions represented, documented species totals, species lists, and the percentage of the working species pool in each combination.

| Province combination | No. provinces | Species | Species list | % all species |
|---|---|---|---|---|
| Yunnan only | 1 | 125 | *Alysson attenuatus; Alysson caeruleus; Alysson carinatus; Alysson yunnanensis; Brachystegus ciliosus; Carinostigmus capiconvergens; Carinostigmus latidentatus; Carinostigmus longivertex; Carinostigmus maior; Carinostigmus palawanensis; Carinostigmus rugipunctatus; Carinostigmus triangularis; Carinostigmus vesulcatus; Cerceris latibalteata; Cerceris rufiabdominalis; Cerceris yunnanensis; Cerceris zygomeiosis; Crossocerus aswad; Crossocerus barbipes; Crossocerus carinicollaris; Crossocerus cetratus; Crossocerus rudipunctatus; Crossocerus strangulatus; Crossocerus unidentatus; Dasyproctus cevirus; Dasyproctus idrieus; Dasyproctus vaporus; Ectemnius continuus; Ectemnius dives; Ectemnius nigritarsus; Encopognathus rochei; Encopognathus sudesticus; Encopognathus thaianus; Entomognathus aneurytibialis; Entomognathus yunnanensis; Lestica breviantennata; Liris claviformis; Liris clypefoveolatus; Liris retirugosus; Lyroda curvicarina; Lyroda multidentis; Lyroda retirugosa; Lyroda salai; Lyroda tridentata; Mimesa grandii; Mimesa rhyssocephalica; Mimumesa atratina; Mimumesa melanosomatica; Nitela collaris; Nitela noncrenulata; Nitela obliquipropodea; Nitela protuberancis; Nitela rugosa; Nitela transcarinata; Nitela tumidiscuta; Nitela vecarinata; Nitela williamsi; Oxybelus flagellifoveolaris; Oxybelus mucronatus; Passaloecus birugatus; Passaloecus clypearcuatus; Passaloecus columnaris; Passaloecus insignis; Passaloecus labrinigratus; Passaloecus margdentatus; Passaloecus sp.; Pemphredon chaoi; Pemphredon inornata; Pison irramulus; Polemistus divaricatus; Polemistus fukuitor; Polemistus palawanensis; Polemistus pediflavidus; Psen affinis; Psen brinchangensis; Psen fronistriatus; Psen rufoannulatus; Psen scabristriatus; Psen seminitidus; Psen yunnanensis; Psenulus bicinctus; Psenulus carinitibialis; Psenulus lubricus; Psenulus suifuensis; Rhopalum coarctatum; Rhopalum dentiobliquum; Spilomena capatrata; Spilomena clypei; Spilomena hainesi; Spilomena menkei; Spilomena rhytithoracica; Stigmus carinannulatus; Stigmus flagellipilaris; Stigmus fronticoncavus; Stigmus nullirugatus; Stigmus rugibrevis; Stigmus rugidensus; Stigmus rugilongus; Stigmus sulciconspicus; Stigmus tibisulcatus; Tachytes monetarius; Tachytes yunnanensis; Trypoxylon aphelothoracicus; Trypoxylon bifoveatum; Trypoxylon bilobatum; Trypoxylon buddha; Trypoxylon clypeisinuatum; Trypoxylon ferrugineipes; Trypoxylon flavipes; Trypoxylon fulvocollare; Trypoxylon gampahae; Trypoxylon infoveatum; Trypoxylon interruptum; Trypoxylon kandyianum; Trypoxylon khasiae; Trypoxylon maculipes; Trypoxylon nasale; Trypoxylon pahangense; Trypoxylon pendleburyi; Trypoxylon similichingi; Trypoxylon thaianum; Trypoxylon truncatum; Tzustigmus khmer; Tzustigmus pesangulatus; Tzustigmus syam* | 78.1 |
| Sichuan only | 1 | 9 | *Alysson nigrilabius; Alysson sichuanensis; Carinostigmus filippovi; Cerceris tuberidentalis; Crossocerus medidentatus; Crossocerus sulcatus; Lestiphorus rugulosus; Psen lacuniventris; Rhopalum rubigabdominale* | 5.6 |
| Xizang Autonomous Region only | 1 | 8 | *Crossocerus xizangensis; Mimesa infossa; Mimumesa dahlbomi; Odontopsen shii; Oxybelus nigrilamellatus; Passaloecus edentutus; Psen rhyssothoracicus; Stigmus interruptus* | 5 |
| Yunnan + Guizhou | 2 | 5 | *Carinostigmus costatus; Carinostigmus frontirugatus; Cerceris wroughtoni; Psenulus orinus; Stigmus lobomelanicus* | 3.1 |
| Guizhou only | 1 | 4 | *Alysson cyanotaeniatus; Psen spinitarsalis; Trypoxylon imayoshii; Trypoxylon shimoyamai* | 2.5 |
| Sichuan + Guizhou | 2 | 4 | *Crossocerus binicarinalis; Crossocerus pleuralituberculi; Rhopalum cornilabiatum; Rhopalum odontodorsale* | 2.5 |
| Yunnan + Xizang Autonomous Region | 2 | 3 | *Crossocerus rugosilateralis; Passaloecus monilicornis; Passaloecus petiolatus* | 1.9 |
| Yunnan + Sichuan | 2 | 2 | *Pemphredon verugosa; Polemistus mindanaonis* | 1.2 |

Note: Province only documentation indicates that a species appears in only one regional list in this compilation. It does not establish endemism, geographic restriction, or confirmed absence from other regions.

**Table S4.** Decadal history of Crabronidae occurrence from 1909 to 2025.

**A.**

| Period | Records | Species | Localities | Years represented | Specimens* |
|---|---|---|---|---|---|
| 1909–1909* | 1 | 1 | 1 | 1 | 1 |
| 1910s | 0 | 0 | 0 | 0 | 0 |
| 1920s | 0 | 0 | 0 | 0 | 0 |
| 1930s | 0 | 0 | 0 | 0 | 0 |
| 1940s | 1 | 1 | 1 | 1 | 1 |
| 1950s | 39 | 23 | 24 | 4 | 89 |
| 1960s | 1 | 1 | 1 | 1 | 1 |
| 1970s | 7 | 5 | 7 | 2 | 17 |
| 1980s | 49 | 33 | 40 | 9 | 56 |
| 1990s | 21 | 16 | 11 | 4 | 45 |
| 2000s | 143 | 62 | 121 | 10 | 431 |
| 2010s | 62 | 36 | 38 | 6 | 266 |
| 2020–2025* | 49 | 34 | 36 | 5 | 117 |

**B.**

| Period | Species | Cumulative species | Start | End | Years available | Period status |
|---|---|---|---|---|---|---|
| 1909–1909* | 1 | 1 | 1909 | 1909 | 1 | Partial beginning decade |
| 1910s | 0 | 1 | 1910 | 1919 | 10 | Complete decade within dataset window |
| 1920s | 0 | 1 | 1920 | 1929 | 10 | Complete decade within dataset window |
| 1930s | 0 | 1 | 1930 | 1939 | 10 | Complete decade within dataset window |
| 1940s | 1 | 2 | 1940 | 1949 | 10 | Complete decade within dataset window |
| 1950s | 23 | 25 | 1950 | 1959 | 10 | Complete decade within dataset window |
| 1960s | 1 | 26 | 1960 | 1969 | 10 | Complete decade within dataset window |
| 1970s | 5 | 31 | 1970 | 1979 | 10 | Complete decade within dataset window |
| 1980s | 26 | 57 | 1980 | 1989 | 10 | Complete decade within dataset window |
| 1990s | 12 | 69 | 1990 | 1999 | 10 | Complete decade within dataset window |
| 2000s | 47 | 116 | 2000 | 2009 | 10 | Complete decade within dataset window |
| 2010s | 26 | 142 | 2010 | 2019 | 10 | Complete decade within dataset window |
| 2020–2025* | 18 | 160 | 2020 | 2025 | 6 | Partial ending decade |

Note: Panel A, the 1909 starting period and the 2020 to 2025 ending period are partial intervals. Specimen totals are descriptive because collection effort was not standardized. Panel B, first representation means the first appearance of a species in this compilation. It should not be interpreted as the first collection, first publication, colonization, or arrival of that species in southwestern China.

**Table S5.** Species level documentation depth based on the number of unique coordinate localities represented for each species.

| Locality class | Species | % species | Interpretation |
|---|---|---|---|
| 1 | 81 | 50.6 | Documented from one unique coordinate locality; not evidence of biological rarity |
| 2–4 | 66 | 41.2 | Documented from two to four unique coordinate localities |
| 5–9 | 11 | 6.9 | Documented from five to nine unique coordinate localities |
| 10–19 | 1 | 0.6 | Documented from ten to nineteen unique coordinate localities |
| ≥20 | 1 | 0.6 | Documented from at least twenty unique coordinate localities |

Note: The locality classes summarize the depth of available occurrence documentation. A species represented by one locality is poorly documented in this dataset, but it is not necessarily biologically rare, endemic, or geographically restricted.

**Table S6.** Crabronidae species based on localities.

| Subfamily | Number of species | Mean unique localities | Median unique localities | Maximum unique localities | Species with one locality |
|---|---|---|---|---|---|
| Crabroninae | 75 | 2.07 | 1 | 20 | 39 |
| Pemphredoninae | 70 | 2.41 | 2 | 19 | 32 |
| Bembicinae | 9 | 1.33 | 1 | 2 | 6 |
| Philanthinae | 6 | 1.67 | 1 | 4 | 4 |

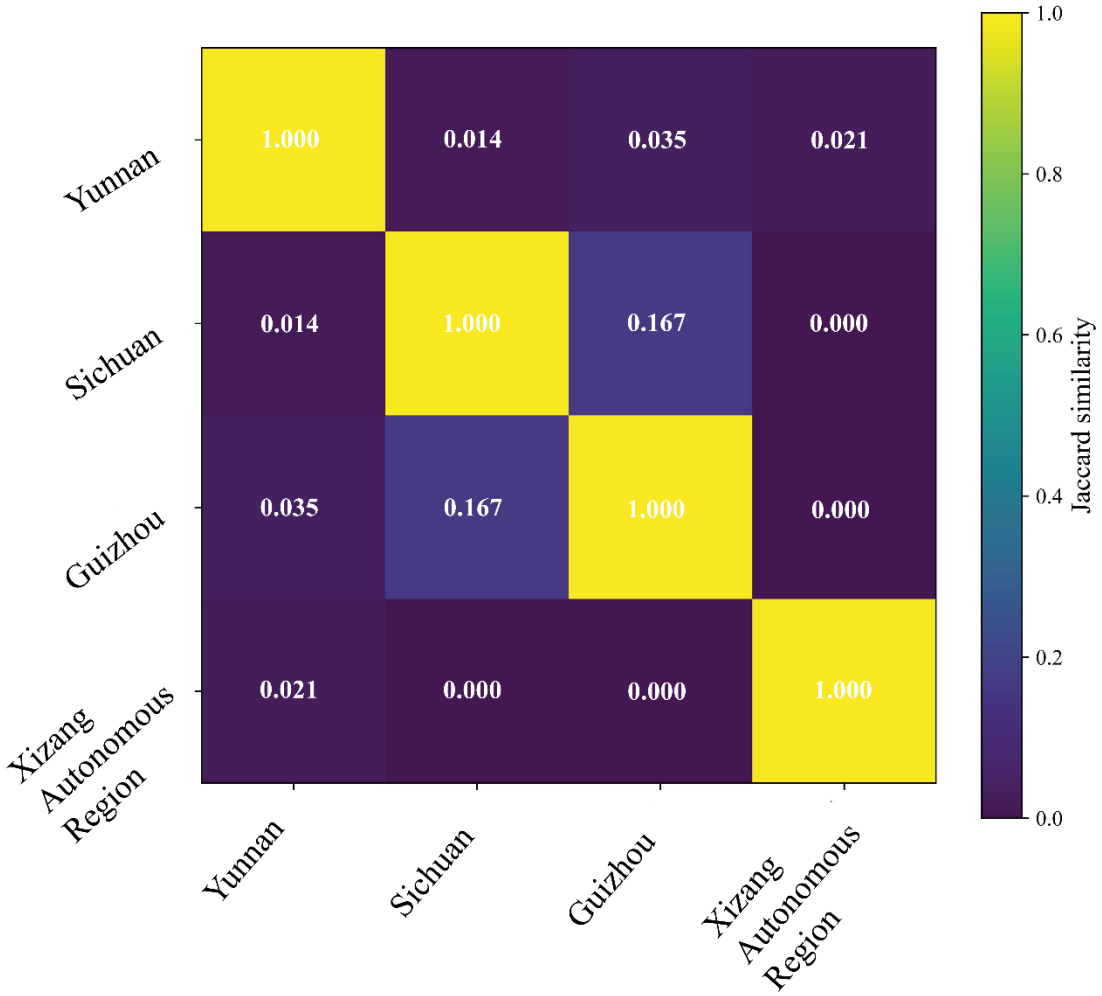



**Figure S1.** Pairwise Jaccard similarity among provincial species of Crabronidae in southwestern China.

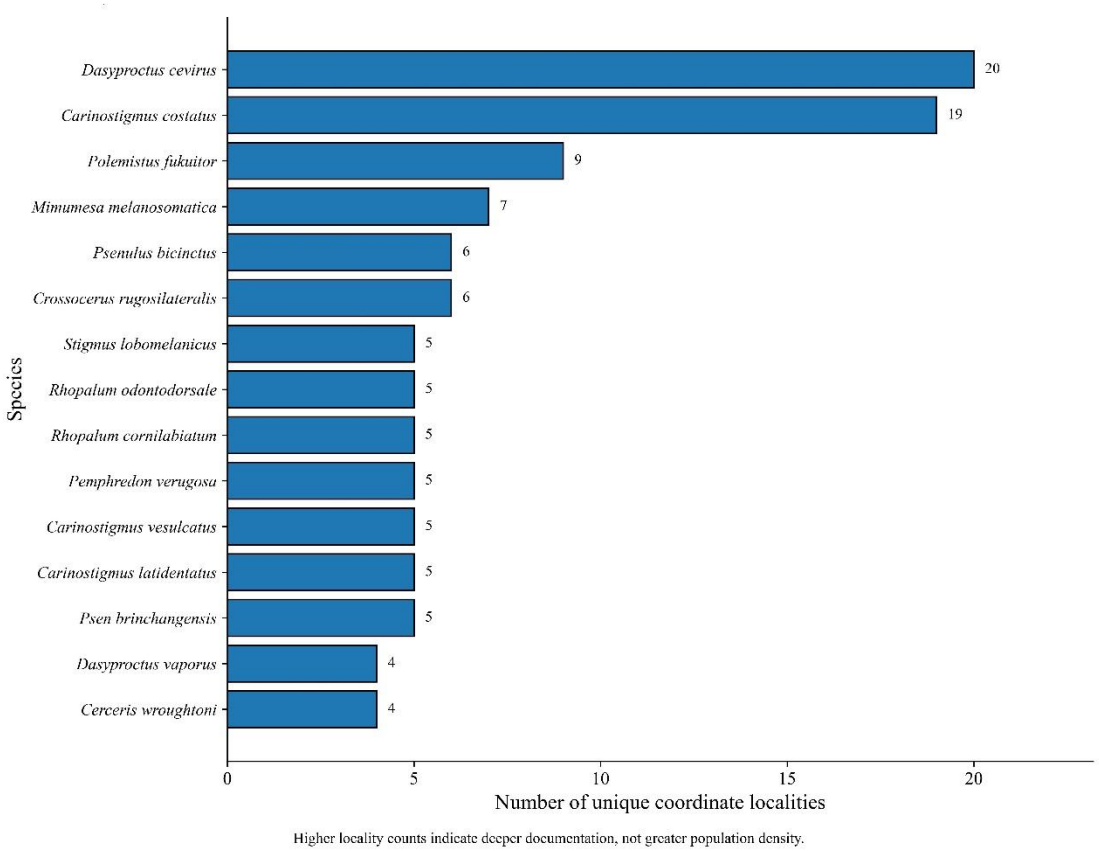



**Figure S2.** Distribution of Crabronidae species across unique localities in southwestern China. The horizontal axis represents the number of localities in which each species was recorded, and the vertical axis lists the corresponding species names.