



<http://dx.doi.org/10.11646/zootaxa.3795.5.6>

<http://zoobank.org/urn:lsid:zoobank.org:pub:CAAFCFB8-4864-41BE-89B0-8FE4CA3925B4>

## Phytoseiidae Database: a website for taxonomic and distributional information on phytoseiid mites (Acari)

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### Abstract

This paper announces a database on the taxonomy and distribution of mites of the family Phytoseiidae Berlese, which is available online at <http://www.lea.esalq.usp.br/phytoseiidae/>. Synthesis of species diversity per genus, subfamily and country are given. Information about use of the database is provided.

**Key words:** biological control, mite, predatory, taxonomy

### Introduction

Phytoseiid mites (Acari: Phytoseiidae) have received great attention from the scientific community due to their potential as biological control agents of phytophagous mites, thrips and whiteflies (Gerson *et al.*, 2003; McMurtry *et al.*, 2013). Several species of this family are presently available commercially for use in agriculture, and can easily be found by a search on the internet.

Present and future biological studies may lead to the discovery of other promising species for pest control, which may be more effective than the species already in use (Gerson *et al.*, 2013; McMurtry *et al.*, 2013). These studies require the precise classification and correct identification of these organisms.

Phytoseiidae is a large family. The first version of the world phytoseiid catalog was published by Moraes *et al.* (1986) and included about 1,500 species in 79 genera. The second version (Moraes *et al.*, 2004) included about 2,200 species in 67 genera; the number of genera in the second version was fewer due to the synonymising of some of the genera. Later, Chant & McMurtry (2007) listed about 2,300 species in 84 genera, while Prasad (2012) mentioned 2,692 species names (including synonyms).

In September 2012, the first version of an electronic database was released for open access on the internet, <http://www.lea.esalq.usp.br/phytoseiidae/> (Demite *et al.*, 2014). The aim of this paper is to report the availability of a new version of that database, describe the methodology used in its preparation, and explain how to use the variety of information it provides.

The Phytoseiidae Database is not a taxonomic revision. It contains no formal taxonomic decisions. Placement of a species under a genus different from which it has been known in the literature should not be considered a "new combination". Thus, no new names are proposed for homonyms that could have resulted from the different placement of species in genera according to the system used in this database, or to homonyms that have already been created in the literature and for which new names have still not been proposed.

### Materials and methods

Type locality is indicated according to collection data for the holotype or type series in the original description.

Distribution of other specimens is generally given in terms of countries where the species has been reported in the literature.

Territories and possessions of a country (e.g., Alaska, Galapagos, Hawaii, etc.), away from its mainland, are mentioned separately from that country. For Australia, Brazil, Canada, China, India, Russia and the United States of America (countries with the largest geographical areas), the distribution is provided in terms of the major political divisions where the species has been reported.

The abbreviation (OBS) indicates the availability of a note concerning the reference immediately before it, which can be seen on the screen by moving the pointer over that abbreviation. Whenever a species was reported in a publication as "aff." or "cf.", the note will read "Questioned identification". If an author questioned the identification given in a previous publication, a note to this effect is given under the species. When an author re-identified specimens previously reported under a different name, the report of the species is given only under the new identification; notes are given under the original and the new identification indicating the change.

The symbol "\*" after a name indicates that it is a junior synonym. The symbol "^" after a species indicates that its assignment to that genus is provisional, either because current available information does not allow its unambiguous classification or because its characteristics do not fit any described genus. Synonymies proposed in the literature were always accepted, except when the literature clearly indicated disagreements between authors.

## Results

Since publication of the last version of the catalog (Moraes *et al.*, 2004), about 450 papers have been published about the taxonomy and/or faunistic surveys of phytoseiid mites. These include descriptions of 24 new genera and about 450 new species, and changes in the generic placement of many species.

At the start of April 2014, there were 2,709 described species of Phytoseiidae (2,436 valid species), in 91 genera and three subfamilies (Amblyseiinae, Phytoseiinae and Typhlodrominae) (Table 1). Amblyseiinae is the largest subfamily in number of described species (1,748) and genera (65). Typhlodrominae and Phytoseiinae have 732 described species in 23 genera and 229 described species in three genera, respectively. The genera with the largest number of described species are *Typhlodromus* (454), *Amblyseius* (400), *Neoseiulus* (397), *Phytoseius* (222) and *Euseius* (213) and *Proprioseiopsis* (163). The remaining genera have at most 93 species; and 34 genera contain only a single described species.

The countries with the highest number of valid species of Phytoseiidae in descending order are USA (313), China (288), India (195), Brazil (190), and Pakistan (178) (Table 2). However, most countries have fewer than 15 species and there are no records for many countries.

This paper presents an updated version of the Phytoseiidae Database, which presents detailed information about the taxonomy and distribution of each species. The database is hosted by a website of the Department of Entomology and Acarology, ESALQ-USP, Piracicaba, São Paulo, Brazil, at <http://www.lea.esalq.usp.br/phytoseiidae/>.

The opening page of the site will allow searches under four headings: 1. *Species*; 2. *Advanced*; 3. *Tree* and 4. *References*. Details about the type of information presented under each heading is subsequently provided.

### 1. Species

This option can be used by typing the full name (or part of the name) of a given phytoseiid species. The result is shown on the screen as a list of species fitting the name (or part of the name) entered, with the corresponding references to the original descriptions. By selecting any name, the subsequent screen will show the following information for the species:

**Classification:** Subfamily, tribe, subtribe, genus, subgenus and species. Some of these ranks are not available for some species.

**Holotype:** *Genus species*: Author, year: page where description starts; type locality and type habitat.

**Synonyms:** With corresponding references.

**Other names:** Other combinations with genera and subgenera under which the species has been associated, with the corresponding first references.

**TABLE 1.** Number of described and valid species of Phytoseiidae (Demite *et al.*, 2014).

| Amblyseiinae            |           |       | Amblyseiinae continued    |           |       |
|-------------------------|-----------|-------|---------------------------|-----------|-------|
| Genus                   | Species   |       | Genus                     | Species   |       |
|                         | Described | Valid |                           | Described | Valid |
| <i>Amblyseius</i>       | 400       | 359   | <i>Neoparaphytoseius</i>  | 1         | 1     |
| <i>Neoseiulus</i>       | 397       | 355   | <i>Paraamblyseiulella</i> | 1         | 1     |
| <i>Euseius</i>          | 213       | 191   | <i>Parachelaseius</i>     | 1         | 1     |
| <i>Proprioseiopsis</i>  | 163       | 138   | <i>Parakampimodromus</i>  | 1         | 1     |
| <i>Typhlodromips</i>    | 93        | 88    | <i>Pholaseius</i>         | 1         | 1     |
| <i>Scapulaseius</i>     | 65        | 62    | <i>Prasadromalus</i>      | 1         | 1     |
| <i>Transeius</i>        | 58        | 54    | <i>Quadromalus</i>        | 1         | 1     |
| <i>Typhlodromalus</i>   | 26        | 22    | <i>Ragusaseius</i>        | 1         | 1     |
| <i>Arrenoseius</i>      | 25        | 24    | <i>Ricoseius</i>          | 1         | 1     |
| <i>Amblydromalus</i>    | 23        | 20    | <i>Rubuseius</i>          | 1         | 1     |
| <i>Paraphytoseius</i>   | 22        | 19    | <i>Serraseius</i>         | 1         | 1     |
| <i>Ueckermannseius</i>  | 21        | 21    | <i>Swirskiseius</i>       | 1         | 1     |
| <i>Graminaseius</i>     | 19        | 16    | <i>Tenuisternum</i>       | 1         | 1     |
| <i>Okiseius</i>         | 18        | 17    | Total for 65 genera       | 1,748     | 1,570 |
| <i>Kampimodromus</i>    | 17        | 15    | Phytoseiinae              |           |       |
| <i>Amblyseiulella</i>   | 15        | 15    | Genus                     | Species   |       |
| <i>Phytoscutus</i>      | 15        | 14    |                           | Described | Valid |
| <i>Gynaeseius</i>       | 13        | 11    | <i>Phytoseius</i>         | 222       | 203   |
| <i>Chelaseius</i>       | 11        | 11    | <i>Platyseiella</i>       | 6         | 6     |
| <i>Proprioseius</i>     | 11        | 10    | <i>Chantia</i>            | 1         | 1     |
| <i>Iphiseiodes</i>      | 10        | 10    | Total for 3 genera        | 229       | 210   |
| <i>Paragigagnathus</i>  | 10        | 9     | Typhlodrominae            |           |       |
| <i>Aristadromips</i>    | 9         | 8     | Genus                     | Species   |       |
| <i>Paraamblyseius</i>   | 9         | 9     |                           | Described | Valid |
| <i>Phytoseiulus</i>     | 9         | 4     | <i>Typhlodromus</i>       | 454       | 415   |
| <i>Eharius</i>          | 7         | 6     | <i>Metaseiulus</i>        | 55        | 43    |
| <i>Asperoseius</i>      | 6         | 5     | <i>Neoseiulella</i>       | 47        | 39    |
| <i>Tenorioseius</i>     | 5         | 4     | <i>Kuzinellus</i>         | 46        | 46    |
| <i>Amblyseiella</i>     | 4         | 2     | <i>Paraseiulus</i>        | 25        | 18    |
| <i>Knopkirie</i>        | 4         | 4     | <i>Galendromus</i>        | 20        | 18    |
| <i>Proprioseiulus</i>   | 4         | 4     | <i>Meyerius</i>           | 18        | 18    |
| <i>Chilaseius</i>       | 3         | 2     | <i>Chanteius</i>          | 12        | 9     |
| <i>Olpiseius</i>        | 3         | 3     | <i>Typhloseiulus</i>      | 10        | 10    |
| <i>Phytodromips</i>     | 3         | 3     | <i>Cydnoseius</i>         | 8         | 4     |
| <i>Flagroseius</i>      | 2         | 1     | <i>Typhlodromina</i>      | 7         | 6     |
| <i>Iphiseius</i>        | 2         | 1     | <i>Typhloseiopsis</i>     | 7         | 7     |
| <i>Kampimoseiulella</i> | 2         | 2     | <i>Australiseiulus</i>    | 6         | 6     |
| <i>Pararrenoseius</i>   | 2         | 2     | <i>Galendromimus</i>      | 6         | 6     |
| <i>Phyllodromus</i>     | 2         | 2     | <i>Cocoseius</i>          | 3         | 3     |
| <i>Typhloseiella</i>    | 2         | 2     | <i>Africoseiulella</i>    | 1         | 1     |

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**TABLE 1.** (Continued)

| Amblyseiinae continued. |           |       | Typhlodrominae continued |           |       |
|-------------------------|-----------|-------|--------------------------|-----------|-------|
| Genus                   | Species   |       | Genus                    | Species   |       |
|                         | Described | Valid |                          | Described | Valid |
| <i>Afrodromips</i>      | 1         | 1     | <i>Africoseiulus</i>     | 1         | 1     |
| <i>Afroseiulus</i>      | 1         | 1     | <i>Breviseius</i>        | 1         | 1     |
| <i>Amblymexica</i>      | 1         | 1     | <i>Gigagnathus</i>       | 1         | 1     |
| <i>Archeosetus</i>      | 1         | 1     | <i>Indiraseiulus</i>     | 1         | 1     |
| <i>Diaphoroseius</i>    | 1         | 1     | <i>Leonseius</i>         | 1         | 1     |
| <i>Evansoseius</i>      | 1         | 1     | <i>Papuaseius</i>        | 1         | 1     |
| <i>Honduriella</i>      | 1         | 1     | <i>Silvaseius</i>        | 1         | 1     |
| <i>Macrocaudus</i>      | 1         | 1     | Total for 23 genera      | 732       | 656   |
| <i>Macroseius</i>       | 1         | 1     | Total Phytoseiidae       |           |       |
| <i>Maunaseius</i>       | 1         | 1     | Genera                   | Species   |       |
| <i>Metadromips</i>      | 1         | 1     |                          | Described | Valid |
| <i>Moraeseius</i>       | 1         | 1     | Total for 91 genera      | 2,709     | 2,436 |

**TABLE 2.** Total valid species of Phytoseiidae by country (Demite *et al.*, 2014).

| Country      | Species* | Country  | Species* |
|--------------|----------|--|----------|
| USA          | 313      | Ghana  | 40       |
| China        | 288      | Cameroon   | 39       |
| India        | 195      | Madagascar (Indian Ocean), Puerto Rico (Atlantic Ocean), Thailand, Tunisia   | 38       |
| Brazil       | 190      | Trinidad (Atlantic Ocean)  | 37       |
| Pakistan     | 178      | Finland, Malawi, Poland, Portugal  | 36       |
| Australia    | 163      | Latvia   | 35       |
| Kenya        | 151      | Burundi, New Zealand (Pacific Ocean)   | 34       |
| South Africa | 134      | Galapagos (Ecuador/Pacific Ocean), Nigeria   | 33       |
| Mexico       | 124      | England, Indonesia (Indian Ocean and Pacific Ocean), Martinique (Atlantic Ocean), Mozambique, Reunion Islands (Indian Ocean) | 31       |
| Greece       | 112      | Austria, Morocco   | 30       |
| Ukraine      | 111      | Guatemala, Jamaica (Atlantic Ocean), Kazakhstan, Serbia, Switzerland   | 29       |
| Russia       | 108      | Chile, Netherlands, Uganda   | 28       |
| Canada       | 100      | Canary Islands (Spain/Atlantic Ocean), Malaysia, Rwanda, Zimbabwe  | 27       |
| Japan        | 98       | Nicaragua  | 26       |
| Philippines  | 95       | Guyana   | 25       |
| Costa Rica   | 88       | Ecuador and Papua New Guinea   | 24       |
| France       | 86       | Dominican Republic, El Salvador  | 23       |
| Italy        | 79       | Sierra Leone, Sweden   | 22       |
| Iran         | 76       | Caucasus Region**, Hong Kong, Zambia   | 21       |
| Spain        | 75       | Cyprus, Jordan, Sri Lanka  | 20       |

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**TABLE 2.** (Continued)

| Country   | Species* | Country   | Species* |
|---|----------|---|----------|
| Colombia  | 71       | Marie Galante (Atlantic Ocean), Saudi Arabia, Tanzania  | 19       |
| Germany   | 67       | Croatia, Montenegro   | 18       |
| Turkey  | 65       | Cape Verde, Denmark   | 16       |
| Azerbaijan  | 64       | Czech Republic, New Caledonia (Pacific Ocean)   | 15       |
| Egypt, Hungary                                    | 63       | Slovenia, Sudan, Yemen  | 14       |
| Peru  | 61       | Alaska (USA), Belgium, Lebanon, Les Saintes (Atlantic Ocean), Syria   | 13       |
| Israel  | 59       | Saint Martin (Atlantic Ocean)   | 12       |
| Armenia, Taiwan                                   | 58       | Belarus, Kyrgyzstan, Lesotho, Panama  | 11       |
| Georgia, Honduras, Norway                         | 57       | Angola, Lithuania, Madeira Islands (Portugal/Atlantic Ocean), Paraguay, Tajikistan, Turkmenistan, Singapore   | 10       |
| Guadaloupe (Atlantic Ocean)                       | 51       | Congo, Vanuatu (Pacific Ocean)  | 8        |
| Algeria   | 50       | Fiji (Pacific Ocean), La Désirade (Atlantic Ocean), Senegal, Tahiti (Pacific Ocean)   | 7        |
| Moldova   | 49       | Iceland (Atlantic Ocean), Oman, Saint Barthélemy (France/ Atlantic Ocean)   | 6        |
| South Korea                                       | 48       | Cook Islands (Pacific Ocean), Ivory Coast, Namibia, Uruguay, Uzbekistan   | 5        |
| Cuba (Atlantic Ocean), Hawaii (USA/Pacific Ocean) | 47       | Bulgaria, Fernando de Noronha (Brazil/Atlantic Ocean), Saint Lucia (Atlantic Ocean), Suriname   | 4        |
| Argentina, Benin                                  | 46       | Albania, Belize, Bosnia and Herzegovina, Mauritius (Indian Ocean), Northern Ireland, Seychelles (Indian Ocean), United Arab Emirates  | 3        |
| Democratic Republic of the Congo                  | 45       | Antigua (Atlantic Ocean), Bolivia, Gaza Strip, Futuna Island (Pacific Ocean), Greenland (Denmark/Arctic Ocean and Atlantic Ocean), Guinea, Liberia, Macedonia, Togo, West Bank, West Samoa (Pacific Ocean)  | 2        |
| Slovakia  | 43       | Barbados (Atlantic Ocean), Bermuda (Atlantic Ocean), Comores, Equatorial Guinea, French Guiana (France), French Polynesia (France/Pacific Ocean), Gilbert Islands (Kiribati/Pacific Ocean), Haiti, Ireland, Libya, Romania, Saint Kitts (Atlantic Ocean), Scotland, Tortola Islands (United Kingdom/Atlantic Ocean), US Samoa (USA/Pacific Ocean), Wallis Island (France/Pacific Ocean) | 1        |
| Venezuela   | 42       |   |          |

\* excluding questionable identifications; \*\* country not stated.

**Distribution** (region and or country): With the corresponding references.

**Redescription:** References in addition to the original description providing morphological information about the species.

**Catalog:** references providing lists of phytoseiid species in a region, including the species under consideration, based on published information and providing no new information on other items treated in the catalog.

**Biosystematics:** references to crossing studies that corroborate the distinction between two or more species;

**Molecular Characterisation:** references about studies of molecular characterisation of the species.

**Note:** general comments, mostly indicating re-identifications of specimens.

In case of synonymy, all of those items are mentioned for the senior and the junior synonyms. Throughout the text, when pointing to any of the references, the full citation will be shown on the screen.

## 2. Advanced

This option will allow searches according to three factors. The first, *Classification*, allows the selection of a genus name, which when selected by itself will result in the presentation on the screen of a list of species assigned to it; names of junior synonyms are followed by asterisks. The selection of a species name will produce the same result previously described for the selection of *Species*. The second, *Distribution*, allows the search for species reported from a given country. For the seven largest countries, it is possible to select the first political subdivision within the country, by selecting the State in the window *Subregion*. The third, *Host / Substrate*, allows a search of the phytoseiid holotypes reported from each substrate, or from each plant family (*Plant family*). Upon selection of a plant family, search can also be done for plant species within that family (*Host species*). In the future, this information will be provided for all published records of each phytoseiid species, and not only for the holotypes.

## 3. Tree

This option will show a list of phytoseiid genera and the species within each genus, in alphabetical order. The selection of one of the species will produce the same result previously described for the selection of *Species*.

## 4. Reference

This option will open a new screen with three windows, allowing a search for papers on phytoseiid taxonomy and distribution, by one author or by a combination of up to three authors.

## Discussion

The availability of updated catalogs facilitates the work of world taxonomists. A few databases on mite taxonomy are presently available online. The first database (The Biology Catalog; <https://insects.tamu.edu/research/collection/hallan/Acari/0ReportHi.htm>) was made available by Hallan (2005). One of these (Miteresearch.org; <http://www.miteresearch.org/index1.html>) lists the names of mite species in all groups. Presently, over 58,000 names are listed, with references to the respective original descriptions (Schmidt, 2014). Another database (Spider Mite Web; <http://www1.montpellier.inra.fr/CBGP/spmweb/>), provides information about Tetranychidae mites (Migeon & Dorkeld, 2014). Databases of other mite groups can be accessed through the Catalog of Life (Roskov *et al.*, 2013; <http://www.catalogueoflife.org/>): Bdelloidea (Den Heyer, 2013), Ixodida (Nijhof *et al.*, 2013), Ologamasidae (Castilho *et al.*, 2013a), Phytoseiidae (Castilho *et al.*, 2013b), Rhodacaridae (Castilho & Moraes, 2013), Tenuipalpidae (Mesa *et al.*, 2013) and Tetranychidae (Migeon & Dorkeld, 2013).

Due to the dynamism of the research on phytoseiid mites, the Phytoseiidae Database is an important tool to allow information to be updated quickly, which is of great importance given the dynamism of the publications on this group. We would appreciate being informed of any possible omissions or errors, so that corrections and additions can be made.

## Acknowledgements

Postdoctoral fellowship financial support to Peterson Rodrigo Demite was provided by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo, Proc. no. 2011/08941–3).

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