# THE SYSTEMATIC STATUS OF ARACHNIDA,[1] EXCLUSIVE OF ACARI, IN NORTH AMERICA NORTH OF MEXICO

Jonathan A. Coddington[2], Scott F. Larcher[2],
and James C. Cokendolpher[3]

## Introduction

This paper reviews the diversity, distribution, and taxonomic status of North American arachnids, exclusive of Acarina (ticks and mites), and the people who work on them. For the purposes of this paper, "North America" is taken to be continental North America north of Mexico. Our figures represent only recent taxa; fossils are excluded. We attempt to identify endangered taxa, officially listed or otherwise, causes for their jeopardized status, and other systematic areas that might require urgent attention. We also touch on the status and future of North American arachnology in terms of the age structure of arachnologists and their prospects for funding and positions.

Current taxonomies of any arachnid group in North America are disputable. Our great ignorance makes taxonomic disagreements inevitable. Because of disparate taxonomies, one cannot arrive at an exact figure for the numbers of families, genera, or species of arachnid orders in North America. Nevertheless, Roth (1985) reported exact figures for the number of undescribed species in several spider families in North America. Such exact figures may mislead, and so we round our estimates to reflect what we think are "significant figures" in such educated guesses.

The class Arachnida, excluding the Acarina, consists of 10 orders, all of which occur in North America (Table 1). Altogether, roughly 114 families, 689 genera, and 4200 species of non-acarine arachnids are currently known to occur in North America. As a very rough guess, this is probably about 3/4 of the total species that actually occur. Araneae, Opiliones, Pseudoscorpiones, Solifugae, and Scorpiones are widespread and diverse throughout North America, whereas Schizomida, Amblypygi, Palpigradi, Ricinulei, and Uropygi have more restricted southern or western distributions, and are orders of magnitude less diverse (Table 1).

Future discoveries of new North American species of arachnids will probably be confined overwhelmingly to Araneae, Pseudoscorpiones, and Opiliones, in that order. Ironically, patterns in recruitment and age structure of arachnologists specializing on the North American fauna suggest that no taxonomic expertise will be available for Pseudoscorpiones, and that coverage of Araneae and especially Opiliones by specialists will be uneven. Although much of arachnology should still concern the description of new taxa or modern redescription of existing taxa, that need cannot now be met by the existing population of systematists, and the gap will probably get worse because of the age structure of North American arachnologists.

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[1] Amblypygi, Araneae, Opiliones, Palpigradi, Pseudoscorpiones, Ricinulei, Schizomida, Scorpiones, Solifugae, Uropygi.

[2] Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

[3] 2007 29th Street, Lubbock, Texas 79411.

No serious textbooks on arachnid morphology and taxonomy exist. No keys to currently recognized families of North American arachnids have been published. Inadequate substitutes are small chapters in books on related subjects (usually entomology). By themselves these treatments are insufficient to prepare a naive but broadly trained student to use accurately the primary taxonomic literature. No comprehensive guides to identification of any North American arachnid order exist, excepting those trivial cases where a dozen species or fewer occur. The primary taxonomic literature exists as hundreds of uncoordinated papers, many now unobtainable or rare. These publications treat single groups of moderate size, usually genera but occasionally small families. Consequently, keys to genera of arachnid families are rare, often out-dated, geographically limited, or unreliable. The arachnological community has never achieved sufficient size to contemplate, much less initiate, coordinated series of taxonomic publications on the North American fauna, such as exist for some comparably diverse North American insect groups. Expertise on North American Arachnida, then, presupposes a library that currently is available at perhaps three institutions in the U.S.A. and one in Canada, collections that exist at perhaps two or three institutions, and training in the basic morphology of each order that remains an oral tradition. In turn, all this means that reliable identifications by nonspecialists in almost all orders is still difficult, if not impossible.

**Table 1.--Estimated Diversity of Non-Acarine Arachnid Orders in North America**

| ORDER | FAMILIES | GENERA | KNOWN SPP. | UNDESC. SPP. |
|---|---|---|---|---|
| Araneae | 64 | 500 | 3400 | 300-700? |
| Pseudoscorpiones | 18 | 100? | 350? | 500? |
| Opiliones | 19 | 60 | 235+ | 250? |
| Solifugae | 2 | 11 | 120? | 10-20? |
| Scorpiones | 5 | 10 | 85-95 | 10? |
| Schizomida | 2 | 2+ | 12 | 20? |
| Amblypygi | 1 | 2 | 3 | 1 |
| Palpigradi | 1 | 2 | 3 | 3 |
| Ricinulei | 1 | 1 | 1 | 0 |
| Uropygi | 1 | 1 | 1 | 0 |
| TOTALS | 114 | 689? | 4200? | 1100-1700 |

## Methods

We mailed a questionnaire to all the members of the American Arachnological Society who have worked extensively on the taxonomy of North American arachnids, and to all members, regardless of subdiscipline, who reside in North America. Of 300 sent, 150 were returned.

Specialists were asked to comment on known and estimated diversity in their areas, groups that especially required revision, or other urgent work. All were asked to identify endangered arachnids, their habitats, and reasons for their endangered status. They were also asked about their ability to train future arachnologists, and their sources of support for arachnid systematic research. Questions also dealt with age, educational level, occupational status, and time devoted to research. Nonsystematists were asked how they obtained identifications of their research specimens.

Additional information concerning taxonomic diversity was collected from Roth (1985), Parker (1982; sections cited separately), Platnick (1989), and the primary taxonomic literature. Information concerning numbers of arachnologists and arachnid systematic collections of North America was taken from C.I.D.A. (1986) and Arnett et al. (1986).

## The Taxonomic Status Of North American Arachnida

### Araneae

The described world fauna of Araneae includes roughly 3000 genera in 105 families (Platnick 1989). The most recent survey (C.I.D.A., 1986) reports 257 members worldwide with an "interest" in systematics of Araneae, although as a rough guess probably only one third that number are practicing taxonomists.

The most recent comprehensive taxonomic treatment of Araneae (Platnick 1989), indicates that the North American fauna includes 64 families [Corinnidae, Cybaeidae, Cyrtaucheniidae, Dolomedidae, Liocranidae, Miturgidae, Nemesiidae, Segestriidae, Tetragnathidae, Titanoecidae, added to the 54 listed in Roth (1985)], about 500 genera, and roughly 3400 species (Table 1). The increase at the family level reflects mainly the dismemberment of para- or polyphyletic families. Dolomedidae, however, is almost certainly a synonym of Pisauridae, and continues to exist and be recognized in catalogues only because no one has yet formally synonymized it. The 10 largest families include 74% of North American spider species, and the 20 smallest families collectively contain only 2% of the species (Fig. 1). Although Roth (1985) estimated 4 additional "undescribed" genera, that estimate is low, as many existing genera are probably polyphyletic. His estimate of 357 undescribed species is probably also low, as these numbers are based upon specimens examined by only a few taxonomists. Roth (1985) made estimates of undescribed species for approximately 11 families and questionnaire respondents made estimates for an additional 4 families. The "undescribed" mygalomorph family mentioned by Roth (1985), referred to *Calisoga*, is now placed in Nemesiidae (Platnick 1989). Spiders occur throughout all parts of North America, including more than 100 species in 11 families dwelling in the Arctic (Danks 1981). Thus far no families are known to be endemic to North America, but at least several dozen genera are endemic.

Survey respondents thought that Linyphiidae (including Erigoninae) most needs revision (Fig. 1). Individuals thought that anywhere between 1/3 and 3/4 of the genera need revision and that 1/3 to 1/2 of the species remain undescribed. Linyphiids remain mostly unidentifiable, even by spider taxonomists. Other large families requiring massive revisionary work include Clubionidae sensu Roth (1985) (1/2 to 3/4 of the genera; perhaps 1/4 of species undescribed), Lycosidae (1/2-3/4 of the genera; perhaps 1/4 of species undescribed), and Salticidae (1/2-3/4 of the genera; 1/4-1/2 the species undescribed). As one example, Roth (1985) accepted a broad definition of Clubionidae, but the more recent literature recognizes four families in its place: Clubionidae, Corinnidae, Liocranidae, and Miturgidae. The same fate probably awaits Amaurobiidae and Agelenidae (Titanoecidae and Cybaeidae, respectively, are two recently popular splinter taxa). Smaller families in need of revision that were specifically mentioned by respondents include Mimetidae, but to that list one could easily add Agelenidae, Amaurobiidae, Corinnidae, Ctenizidae, Filistatidae, Liocranidae, Miturgidae, Mysmenidae, Ochyroceratidae, Oonopidae, Pholcidae, Zodariidae, and Zoridae. The only larger families that are well known are Araneidae, Gnaphosidae, and Theridiidae.

Currently, little work is being done with North American linyphiid or clubionid genera, but various salticid genera and the genus *Mimetus* (Mimetidae) are being revised. Parts of Agelenidae, Dipluridae, Lycosidae, Pholcidae, Salticidae, Thomisidae, and all of Amaurobiidae, Antrodiaetidae, Anyphaenidae, Aphantochilidae, Araneidae, Atypidae, Ctenidae, Desidae, Dic-

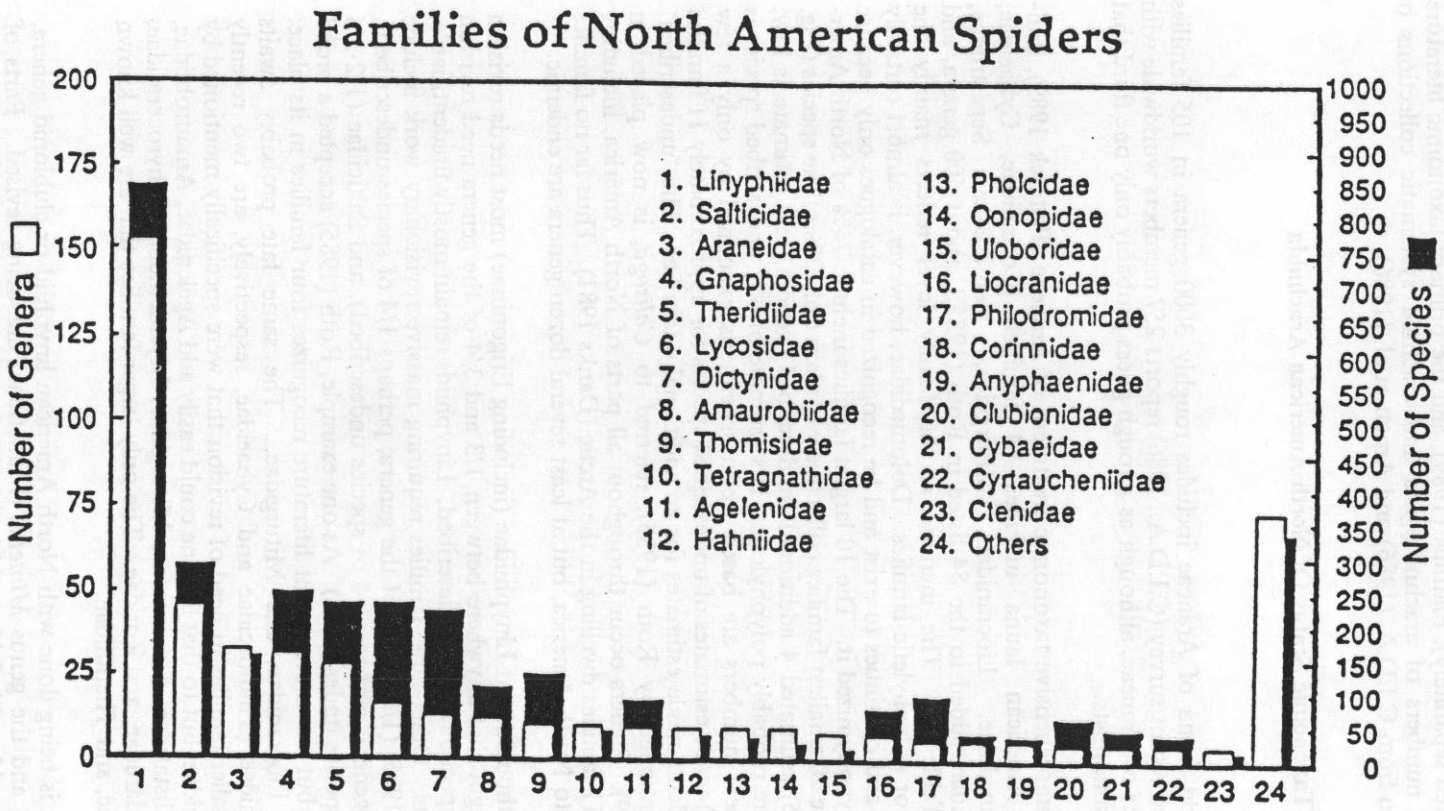


**Figure 1.** Estimated numbers of spider genera and species in North America for the 23 most speciose families, and remaining 41 families ("others"). Note different scales of ordinates.

tynidae, Diguetidae, Gnaphosidae, Hahniidae, Heteropodidae, Homalonychidae, Hypochilidae, Leptonetidae, Loxoscelidae, Mecicobothriidae, Nesticidae, Oecobiidae, Oxyopidae, Philodromidae, Pisauridae, Plectreuridae, Scytodidae, Selenopidae, Symphytognathidae, Tetragnathidae, Theridiidae, Theridiosomatidae, and Uloboridae have had major revisions within the last 30 or so years, although some of them are again out of date (e. g., Amaurobiidae and Dictynidae). Roth (1985) and the yearly bibliographies produced by C.I.D.A. (1966-1988) are good introductions to the taxonomic literature on the North American fauna.

**Pseudoscorpiones**

The described world pseudoscorpion fauna comprises about 23 families and 380 genera (Muchmore 1982). C.I.D.A. (1986) reports 37 members worldwide with an "interest" in systematics of pseudoscorpions, although probably only a third of those are active taxonomists.

Pseudoscorpions in North America include 18 families, 100 genera, and about 350 species (Table 1; W.B. Muchmore, pers. comm.). They occur throughout almost all parts of North America. They are most diverse in California (Hoff 1958). Although only one species has been collected in the high Arctic zone (C. D. Dondale, pers. comm.), 5 species have been recorded from Canada (Dondale 1979). As many as 75% of the North American genera need revision, and as many as 50% of the North American species remain undescribed (W. B. Muchmore, pers. comm.). The families most in need of revision are Chernetidae, Chthoniidae, Cheiridiidae, Withiidae, Olpiidae, and Ideoroncidae. Hoff (1958) gave a list of North American pseudoscorpions, with a key to 69 genera, but obviously it is also out-dated. General treatments are Chamberlin (1931) and Beier (1932a, 1932b). The best access to the literature is via the annual C.I.D.A. lists or Zoological Record, although Hoff (1949) remains a useful guide to some of the higher North American taxa.

**Opiliones**

The described world fauna of Opiliones comprises roughly 28 families and 800 genera (Shear 1982). The most recent survey (C.I.D.A. 1986) reports 54 members worldwide with an "interest" in systematics of opilionids, although as a rough guess probably only one-third that number are practicing taxonomists.

Correspondents estimated that 19 families, 60 genera, and more than 235 described species occur in North America (Table 1). Opiliones occur throughout North America, but the greatest taxonomic diversity is on the West Coast, with several endemic families and subfamilies [Pentanychidae (2 genera), Paranonychidae (2 genera), Ceratolasmidae (2 genera), and Ortholasmatinae (2 genera)] and approximately 9 additional endemic genera (Shear, pers. comm.). Many of the families require revision, and the higher classification is especially chaotic. The single North American Cyphophthalmi family (Sironidae) has been recently reviewed (Shear 1980). Laniatores are probably less well known and their classification is probably more artificial than Palpatores. Phalangodidae (world-wide) is egregiously polyphyletic, and in addition as many as 75% of the genera require revision. Correspondents suggest that about 1/4 of ceratolasmid and phalangiid genera need revision. Various portions of the genera of Cladonychidae (31-50%), Sabaconidae (50%), Gagrellidae (51-75%), and Sclerosomatidae (> 75%) require revision. Several families have been recently revised or are known only by introduced species from Europe (Trogulidae, Nemastomatidae, Caddidae, Pentanychidae, Paranonychidae, and Travuniidae). No estimates for the other families were provided. Several genera remain unplaced in families (Roth and Cokendolpher, unpubl.). Estimates of undescribed species range from 10% to 75% depending on the family in question. All correspondents agreed that the higher classification of opilionids urgently needs work. A key to world laniatorid families based on Roewer (1923) and now out-dated was presented by Briggs (1969). Although Roewer (1923) still serves as a starting point for a review of the older litera-

ture, scattered generic revisions listed in C.I.D.A. yearly bibliographies should be sought. A key to most of the described North American species should appear in a book chapter by Edgar (in press).

**Solifugae**

The described world solifuge fauna comprises 11 families and about 150 genera (Maury 1980, Muma 1982). The most recent survey (C.I.D.A. 1986) reports 14 members worldwide with an "interest" in systematics of solifuges, although as a rough guess probably only one fourth that number are practicing taxonomists.

In North America the families Eremobatidae (roughly 106 species) and Ammotrechidae (roughly 14 species) occur, totalling about 120 species distributed among 11 genera (Table 1). Solifuges have a limited North American distribution (Arkansas, Arizona, California, Colorado, Florida, Georgia, Idaho, Kansas, Louisiana, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Utah, Washington, Wyoming), but *Eremobates septentrionalis* Muma and 4-5 undescribed species have been collected in Canada (Muma 1970; Muma and Holmberg, pers. comm.). Most species are from the Southwest. Less than 10% of the North American species remain to be described (Muma, pers. comm.).

**Scorpiones**

The described world scorpion fauna comprises 9 families and 122 genera (Francke 1982, 1985; Stockwell 1988; S. A. Stockwell, pers. comm.). The most recent survey (C.I.D.A. 1986) reports 46 members worldwide with an "interest" in systematics of scorpions, although as a rough guess probably less than one fourth that number are practicing taxonomists.

Four (or five) families occur in North America, depending on taxonomic opinion (Buthidae, [Chactidae], Diplocentridae, Iuridae, and Vaejovidae), comprising 10 genera (*Anuroctonus*, *Centruroides*, *Diplocentrus*, *Hadrurus*, *Paruroctonus*, *Serradigitus*, *Superstitionia*, *Tityus* (introduced), *Uroctonus*, *Vaejovis*) and approximately 85-95 species, from southern Canada (*Paruroctonus boreus* (Girard)) southwards throughout most of the United States (Table 1). Probably fewer than a dozen species remain undescribed. Workers disagree on what fraction (10%-75%?) of the fauna require revision. Authors agree that the higher classification of scorpions needs work most urgently, especially the monophyly and relationships of the "chactoid" families (Chactidae, Iuridae, and Vaejovidae).

**Schizomida**

The world schizomid fauna consists of 2 families and 5 genera (Levi 1982). The most recent survey (C.I.D.A. 1986) reports 21 members worldwide with an "interest" in the systematics of Schizomida, Uropygi, and Amblypygi together, although as a rough guess probably only 4-5 are active schizomid taxonomists.

Both Protoschizomidae and Schizomidae occur in North America, with 12 species in two or more genera from Arizona, California, Florida, and Texas (Table 1). Of the two families, protoschizomids need more work because generic limits are chaotic and as many as 3/4 of the species are undescribed. A revision of this primarily Mexican family is underway (Reddell & Cokendolpher, in prep.). Rowland and Reddell (Rowland 1972; Rowland and Reddell 1979a, 1979b, 1980, 1981) have treated the New World Schizomidae, but new collections and examinations of Old World species reveal that many species and several genera await naming.

**Amblypygi**

The world amblypygid fauna comprises 4 families and 17 genera (Mullinex 1975; Quintero 1976, 1980, 1981, 1986). Four species of one family, Phrynidae, occur in North America: *Phrynus marginemaculatus* (C. L. Koch) from Florida, *Phrynus operculatus* Pocock from Texas, and *Acanthophrynus coronatus* (Butler) from Arizona and California (Table 1). The fourth, *Paraphrynus* sp. from Texas, is undescribed (D. Quintero, pers. comm.).

**Palpigradi**

The world palpigrade fauna consists of a single family, Eukoeneniidae, and 5 genera (Rowland and Sissom 1980). The most recent survey (C.I.D.A. 1986) reports 5 members worldwide with an interest in systematics of Palpigradi, and all of them have published on palpigrade taxonomy at one point or another.

*Eukoenenia florenciae* (Rucker) and *Prokoenenia wheeleri* (Rucker) occur in Texas, and *Prokoenenia californica* Silvestri occurs in California (Table 1). Three as yet undescribed *Prokoenenia* species are known from California and Oregon (T.S. Briggs. pers. comm.), and a fourth (juveniles only) is known from Florida. Palpigrade taxonomy has been treated by Rowland and Sissom (1980).

**Ricinulei**

The world ricinuleid fauna is included in one family, Ricinoididae, with 3 genera (Platnick 1980; N.I. Platnick, pers. comm.). The most recent survey (C.I.D.A. 1986) reports 10 members worldwide with an interest in systematics of ricinuleids, and about 6 of these are practicing taxonomists.

One species, *Pseudocellus dorotheae* (Gertsch and Mulaik), occurred in Texas, but it may have been extirpated (Table 1).

**Uropygi**

The world uropygid fauna is comprised of two families, Hypoctonidae and Thelyphonidae, with 16 genera (Rowland and Cooke 1973). Three to five systematists worldwide have published on uropygid systematics in the last decade. One species, *Mastigoproctus giganteus* (Lucas), occurs in the Gulf states and west to Arizona with reports from California (Table 1).

## Endangered Species And Their Habitats

Three species of non-acarine arachnids have recently been listed by the Office of Endangered Species at the Fish and Wildlife Service (FWS) (United States Department of the Interior) as Endangered. *Microcreagris texana* Muchmore (Pseudoscorpiones: Neobisiidae), *Texella reddelli* Goodnight and Goodnight (Opiliones: Phalangodidae) and *Leptoneta myopica* Gertsch (Araneae: Leptonetidae), all from Tooth Cave (and a few adjacent caves) in Travis Co., Texas, were the first arachnids to be so listed (Chambers and Jahrsdoerfer 1988).

However, several arachnid species are being reviewed for listing by the FWS (J. Tate and J. Fay, pers. comm.). These are: *Meta dolloff* Levi (Araneae: Tetragnathidae) from Californian caves; an undescribed spider (Telemidae: *Usofila* n. sp.) from Santa Cruz, California; *Microcreagris imperialis* Muchmore (Pseudoscorpiones: Neobisiidae) from Santa Cruz, California; *Cyclocosmia torreya* Gertsch and Platnick (Araneae: Ctenizidae) from Florida;

*Cesonia irvingi* (Mello-Leitao) (Araneae: Gnaphosidae) from the Florida Keys; *Lycosa ericeticola* Wallace (Araneae: Lycosidae) from Florida sandhills; and *Sosippus placidus* Brady (Araneae: Lycosidae), which formerly inhabited xeric sandhills in Florida and may already be extinct. Once the review process is complete, these species may also be listed as Endangered or Threatened. The proposed listing of the Hawaiian spider *Adelocosa anops* Gertsch (Lycosidae) was withdrawn, even though it is known from only a single small cave.

Staff biologists at the Office of Endangered Species at the Fish and Wildlife Service expressed considerable frustration that arachnologists and speleologists may already be aware of arachnids that are endangered, but that they fail to inform the FWS until the situation is critical. The FWS urges all concerned arachnologists to bring potential cases to their attention as soon as they suspect a problem, because at least a year is required to list a taxon, and thus to provide it with some measure of protection.

In all cases correspondents felt that these species are endangered chiefly or solely by continued or potential habitat destruction in conjunction with very restricted ranges. Most of the above species are cave-dwellers, but others occupy less specific habitats, such as sandy pine scrub. Judging from the taxonomic survey above, the rarest and most threatened taxa tend to be concentrated in California and peninsular Florida.

Two species are listed in the Red Data Book (I. U. C. N. 1983). *Pardosa diuturna* Fox (Araneae: Lycosidae) is listed as rare, not known to be in jeopardy, from glacial moraines from southern Alaska to Vancouver Island, and *Banksula melones* Briggs (Opiliones: Phalangodidae) from California caves is listed as vulnerable. Correspondents suggested several other arachnid species whose status should be reviewed. Virtually all these species as well are threatened with habitat destruction, usually resulting from encroaching development. Many are burrowing species and several are cave dwellers.

The Araneae suggested as threatened or endangered are: *Rhechosticta* (= *Aphonopelma*) *reversum* (Chamberlin) (Theraphosidae); *Bothriocytrum californicum* (O. Pickard-Cambridge) (Ctenizidae); *Geolycosa wrightii* (Emerton) (Lycosidae); *Sphodros coylei* Gertsch & Platnick (Atypidae); *Nesticus brimleyi* Gertsch, *Eidmanella reclusa* Gertsch (Nesticidae); all *Lutica* species (Zodariidae); *Geolycosa xera* McCrone (Lycosidae); *Tutelina formicaria* Emerton (Salticidae); *Hypochilus* spp. (Hypochilidae); and *Microhexura montivaga* Crosby & Bishop (Dipluridae).

Correspondents also emphasized that numerous Opiliones are probably threatened or endangered. *Banksula melones* Briggs and *B. martinorum* Briggs & Ubick (Phalangodidae), which inhabit limestone caves in California, may be endangered by quarrying. The type species of the genus, *B. californica* (Banks), may already have become extinct as a result of quarrying operations (D. Ubick, pers. comm.). *"Sitalcina" minor* Briggs and Hom and several other species of *"Sitalcina"* have extremely limited distributions, most being restricted to serpentine grasslands, and are potentially threatened by habitat destruction by development or pesticide and fertilizer spraying. Similarly threatened are six species of *Calicina* known only from small isolates of serpentine grassland surrounding the San Francisco Bay. In addition to *Texella reddelli* Goodnight and Goodnight, which has been granted endangered status, there are seven undescribed species of *Texella* known from single caves (two in California, five in Texas) which receive no protection.

The ricinuleid *Pseudocellus dorotheae* Gertsch and Mulaik and the schizomid *Schizomus mulaiki* Gertsch have not been recollected since 1939 (W.J. Gertsch, pers. comm.), and are known only from the type locality. Both species were collected in the city of Edinburg, Texas, and the schizomid was also known from nearby Rio Grande City and an unspecified locality

on the Rio Grande river perhaps 100 miles northwest of Rio Grande City. This entire area has undergone extensive development. They warrant consideration.

No other species were proposed in response to our questionnaire, but several scorpions, pseudoscorpions, and schizomids have extremely restricted distributions and probably deserve careful consideration.

### The Status Of North American Arachnid Taxonomists

Questionnaire results were used to characterize age, occupation, work time devoted to research, education level, and funding of non-acarine arachnid taxonomists. Of the 150 survey forms returned by the 300 North American recipients, 35 were received from taxonomists, to which we added an additional 5 taxonomists known to us but who did not return the questionnaire. By "taxonomist" we mean someone who has published taxonomic descriptions, name changes, and the like in his or her career.

Of these 40 individuals, 6 are advanced graduate students or have postdoctoral positions. Nine are retired and 2 more are very close to retirement. Fifteen are either unemployed or have jobs where research is neither expected nor encouraged (i.e., 10 said they had no time for research in their jobs). Current "proven reserves" of paid professional arachnid taxonomists thus amounts to about 10 people, 7 of whom work on spiders, 1 on schizomids, 1 on scorpions, and 1 on opilionids. Together they have published on roughly 15 of the 114 arachnid families that occur in North America. This group of specialists either teaches at universities or colleges, or works in museums; and trains most of the students.

This core group is supplemented by the 30 who are retired or unemployed, or whose jobs permit no time for research. Some are nevertheless very prolific, and in fact this group of workers includes the majority of experts on the 6 remaining arachnid orders.

The age structure of systematists differs from that of the remaining arachnologists in that relatively more systematists are present in the older age classes (Fig. 2), and relatively fewer in the earlier age classes. Whereas 25% of the systematists are retired or close to it, only about 6% of the non-systematic arachnid researchers are retired. Nine of those retired systematists were very productive and some taught at major institutions; their loss is especially damaging.

Future training of arachnologists in North America is currently in question because the most productive doctoral program (at Harvard University) may terminate, again because of staff retirement. That program trained 6 of the 10 paid professionals mentioned above. Although 4 of those 10 people potentially could direct Ph.D. theses at their institutions, only 2-3 of those institutions could be considered as having strong programs in systematics.

However, two new programs deserve mention. The University of Maryland at College Park has had a joint graduate program in systematics with the Smithsonian Institution for more than 10 years, and it now encourages arachnid systematics students. Likewise, the American Museum of Natural History has begun a joint graduate program with Cornell University. Both of these programs currently support graduate students in arachnid systematics.

Looking to the future, we see that the greatest threat for North American arachnology is probably the lack of workers on pseudoscorpions, opilionids, and solifuges, in that order. William B. Muchmore was the only person of his generation working on the Pseudoscorpiones, the second most diverse group of arachnids in North America, and no one has taken his place. Martin H. Muma, who worked on solifuges, recently died. No opilionid specialists work in

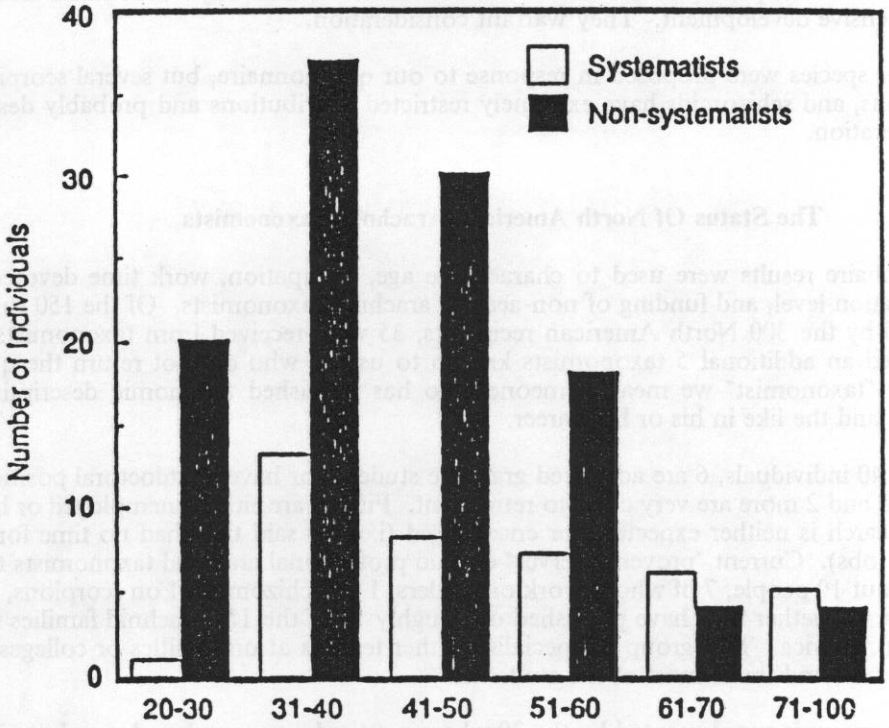


**Figure 2. Age comparison of taxonomic versus non-taxonomic arachnologists.**

major North American museums or universities. After a half-century in which at least one person, and often several, worked on each of the four major arachnid groups, we thus see no younger workers in pseudoscorpions or solifuges, and coverage in opilionids and scorpions is thin. Schizomida, Amblypygi, Uropygi, and Ricinulei do not present many taxonomic problems, although the need for identification continues to be largely unmet.

Funding for systematic research is sparse. Most individuals (43%) receive nothing, and 30% receive less than $1000.00 annually (Fig. 3a). The most common single source of funding is in-house, followed by a miscellany category, and National Science Foundation (Fig. 3b).

### Arachnid Collection Resources

Only four institutions in North America maintain large arachnid collections and support non-acarine arachnid researchers. Two other institutions have substantial collections, but no curators or resident researchers. Information on numbers of type specimens of arachnids is not available from published sources, but the majority of types in North American institutions are in the two largest collections. Of course the types of many common North American species remain in European museums.

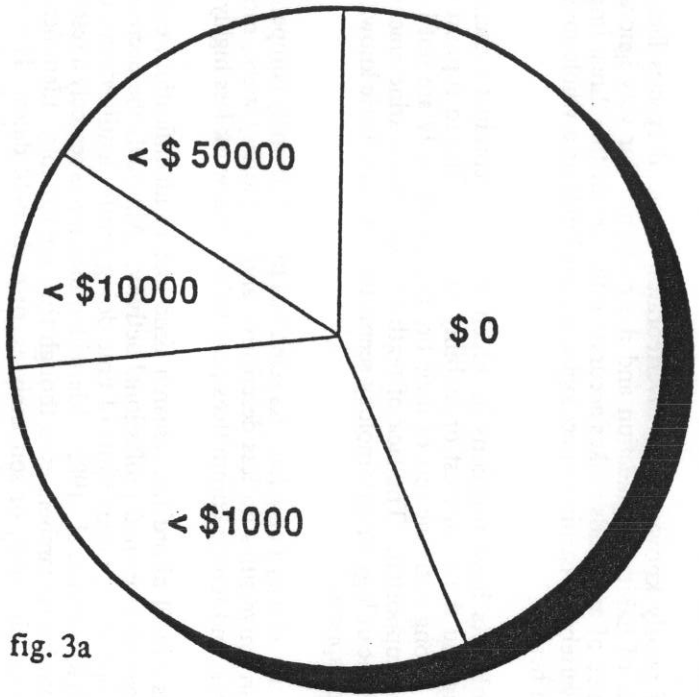


fig. 3a

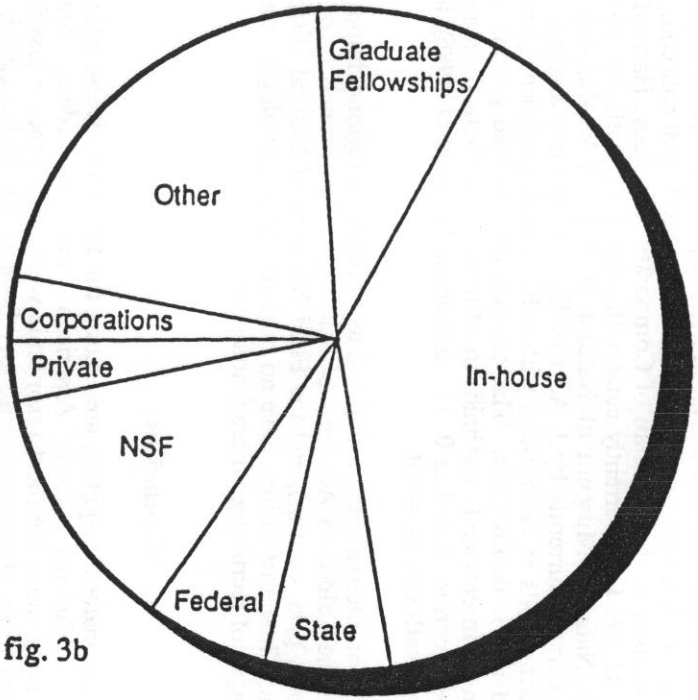


fig. 3b

**Figure 3. Amount (a) and source (b) of funding for arachnid taxonomic research in North America.**

The largest collection in North America (and in the world), with 1.2 million specimens (Arnett et al. 1986), is at the American Museum of Natural History in New York City. N. I. Platnick currently curates the collection with one assistant. The second largest collection, with 0.5-1.0 million specimens, is housed at the Museum of Comparative Zoology, Harvard University (Arnett et al. 1986). H. W. Levi currently curates the collection with one assistant. The Smithsonian Institution (National Museum of Natural History) in Washington, with 0.1-0.25 million specimens, is curated currently by J. A. Coddington with one assistant. The Florida State Collection of Arthropods at Gainesville, with 0.17 million specimens (Arnett et al. 1986), is currently curated by G. B. Edwards. The non-acarine arachnid portion of the Canadian National Collection of Insects and Arachnids in Ottawa, with about 0.144 million specimens (C.D. Donadle, pers. comm.; listed as 0. 115 million in Arnett et al. 1986), is currently curated by C.D. Dondale with one assistant.

Two other collections are of international or national as opposed to regional importance in North America. These are the California Academy of Sciences in San Francisco (ca. 0.09 million specimens, W. Pulawski, pers. comm.), and the Field Museum of Natural History in Chicago (no figures available). These institutions have no non-acarine arachnologists on their research staffs, and show no signs of recruiting for arachnologists.

## Conclusions

Non-acarine arachnids, especially the spiders, are among the ten most diverse arthropod orders in North America. Among North American arachnid orders, Araneae, Pseudoscorpiones, and Opiliones require the most taxonomic work. Opiliones is less diverse than the former two orders, but in an almost compensatory fashion, the higher classification of Opiliones is in much worse condition. Incoherent higher classifications of groups make lucid, workable keys difficult to write, and thus identification becomes very laborious.

Like any other group of poorly known, small invertebrates, arachnid species face extinction almost entirely because of habitat degradation and destruction. Our very ignorance of the distribution and abundance of arachnids makes accurate estimates of this threat impossible. Because they are top invertebrate carnivores ecologically, arachnids as a whole may be sensitive monitors of ecosystem health.

Fewer and fewer arachnologists have positions in which they can conduct systematic studies. Due to lack of funding and the disinterest or inability of universities to support systematics, arachnid taxonomists (along with the rest of their brethren) obviously are not being sufficiently recruited, trained, or supported. The lack of textbooks on non-acarine arachnids comparable to university texts in acarology or entomology seems to mean that basic knowledge essential in arachnology could disappear.

The effects of this demise are already being felt. As scientists in an extremely competitive academic system, taxonomists in universities do less descriptive and revisionary work, mostly because funding sources, agencies, and tenure committees now value such work less highly.

In particular, taxonomists can ill afford the research time lost to identification, exactly because this "service" is no longer an esteemed professional activity. Although the decreasing number of taxonomists already spend undue amounts of time doing *gratis* identifications, they clearly do not meet the demand (Reichert et al. 1985). Mere identification is scarcely a research activity, and thus is inappropriate for researchers even though they are capable. Identification is instead just a service, like water, chemical, or soil analyses, or carbon-14 dates. However, of the arachnid researchers we polled, 26% depend on taxonomic specialists entirely, and 21% identify arachnids by themselves. Even more researchers (77%) consult specialists at some

point, presumably the most critical, in the identification process. Only 2% of the researchers who replied to our survey had used identification services exclusively (7% combined with some other method), partly because so few services are available. It is interesting to speculate that if research taxonomists ceased identifying, the ensuing demand might call forth a mini-industry of "economic taxonomists" whose training would in turn require graduate programs staffed by research taxonomists in appropriate (= collection-supporting) universities. Although we know of no pertinent figures, accurate identifications may already cost several hundred dollars each if staff time and collection/institution overhead are considered.

Although the need for identifications may be the most consistent demand on taxonomy, commitment to basic arachnid systematic research is also necessary, especially in those institutions with important collections that do not yet support arachnologists. Arachnids are a diverse group of organisms whose economic possibilities are only beginning to be exploited (Riechert and Lockley 1984, Jackson and Usherwood 1988). Biocontrol, biotechnology, and neurobiology are only a few of the exciting new scientific specialities that absolutely depend on systematics; how grim the irony if newer disciplines extinguish one of their essential sources.

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