

Taxonomy and identification of dust mites

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Taxonomy provides the basis for the identity of species, allowing the construction of keys and the reliable, reproducible identification of dust mites for ecologic purposes and other studies. Details are given of nomenclatorial conventions in taxonomy as applied to dust mites, and taxonomically problematic entities are highlighted, such as *Blomia kulagini* and the sibling species *Dermatophagoides farinae* and *D. microceras*. Current keys to dust mites and advances in interactive computer keys are reviewed. An hypothesis of the phylogeny of the family Pyroglyphidae is presented, based on habitat specificity, geographic distribution, and association with birds. The value of predictive classifications based on phylogenies is stressed. Finally, a pictorial key is presented to the mites found in house dust in Scandinavia.

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Taxonomy is the science which deals with the recognition, description, and defining of organisms. It provides species, genera, families, or other taxa with an identity which allows them to be recognized reliably and repeatably. For practical purposes, the identity of a taxon is defined by comparing it with related taxa and by defining a combination of characters that are unique to that taxon. It is of relevance to all biologists, because they need to know the identity of the organisms they are working with as accurately as possible if they are to make even the slightest progress with their research.

Why is it so important to know the number of taxonomic entities one is dealing with? Imagine studying the allergens of what had been thought of as a single species, but which turned out to be two. Supposing they have species-specific allergens and that their distribution and biology are different. The result would be that one would draw inaccurate conclusions about the clinical importance of the species, and how many people are exposed to it, with all the ensuing consequences for the management of allergy caused by that species. This has happened with at least one pair of dust-mite species, *Dermatophagoides farinae* and *D. microceras* (1), and has caused considerable confusion. Taxonomic and morphologic differences between these two sibling species have been discussed in detail (2), as have differences in their allergen repertoires (3). Furthermore, species-specific sensitization has been documented (4).

Names and nomenclature

Each of the c. 50 000 described species of mites has a published description of its salient morphologic characters and a scientific name, consisting of a genus name, such as *Dermatophagoides*, and a species name, such as *microceras*. This compound name is called a binomial. The binomial has the advantage that it can be descriptive without being too cumbersome. The name *Dermatophagoides* is derived from the Greek words *dermis* meaning "skin", *phagos*, referring to feeding, and the suffix *-oides* meaning "to look like", and it roughly translates as "thing that looks like those that eat skin". The reason for this name is that Bogdanov (5), the describer of the genus *Dermatophagoides*, thought the mites resembled (but were distinct from) those in the genus *Dermatophagus*, described by Fürstenburg (6) in his treatise on mites associated with scabietic skin diseases. The name *microceras* is derived from the Latin *micro* meaning "small", and *ceres*, meaning "wax"; *cera* means wax image or figure; thus, "small wax figure". The binomial is rooted in a classification: each species is contained within a genus, each genus within a family, each family within an order, and so on. Thus, the name alone is a very convenient means of simplifying information retrieval. The binomial is always written in italics, but the family or other group names are not. After the name, one often sees the name of a person and a date (never printed in italics). This refers to the

Table 1. Classification of *Acarus siro*. Note that not all taxa have common names. Ordinal-subordinal classification of mites is currently unstable and is disputed among acarologists

Category of classification (taxon)	Scientific and common name (in parenthesis) of taxon
Kingdom	Animalia (animals)
Phylum	Arthropoda (arthropods, i.e., those animals with external skeletons and jointed limbs)
Subphylum	Chelicerata (i.e., those arthropods with chelicerate mouthparts and no antennae)
Class	Arachnida (arachnids, i.e., those chelicerates with four pairs of legs and body divided into two distinct regions)
Subclass	Acari (mites, i.e., those arachnids with chelicerate mouthparts plus subcapitulum, with reduced segmentation of posterior body region, and with hexapod larva)
Order	Acariformes (i.e., those mites with leg coxae fused to body, anisotropic setae, dorso-sejugal furrow, and anamorphic postembryonic development)
Infraorder	Sarcoptiformes (i.e., those Acariformes with toothed rutellum, prodorsal differentiation, and no solenidia on tarsus IV)
Suborder	Astigmata (i.e., those Sarcoptiforms with lateral glands and reduced setation of opisthosoma)
Superfamily	Acaroidea
Family	Acaridae (i.e., those Astigmata with clear propodosomal and hysterosomal division, dorsal propodosomal shield, and solenidion σ , at base of tarsus)
Genus	<i>Acarus</i>
Species	<i>Acarus siro</i>

person who first described the species and when they did so.

Classification, phylogeny, and the value of predictive classifications

“Phylogeny” means, loosely, “the history of the tribe”. Reconstructing a phylogeny is similar to compiling a genealogic tree in that both indicate the degree of relatedness between the members of the “tribe”, or taxon. However, a family tree is based on known fact and documentary evidence, whereas a phylogeny is only ever, at best, an hypothesis of the most likely evolutionary history of the taxon.

Classification is not the same as taxonomy. It represents the next step after species and genera have been described, named, and defined. A classification of a group of organisms represents a conceptualization of the hierarchy of its component taxa. If that classification is based on a phylogenetic analysis, then classification and phylogeny are, at least in theory, congruent. In practice, the classification of many groups of organisms may have very little to do with phylogeny, and may represent little more than a “pigeon-holing” system. But, importantly, it serves as a means to make sense of the diversity of those organisms, thus serving as a working hypothesis of relatedness. Table 1 shows how *Acarus siro*, a stored-products mite and a common inhabitant of homes, is classified and some of the most commonly used categories of classification (taxa).

The value of classifications that are based on phylogeny is that they offer a simple, concise information retrieval system that is predictive in nature. For example, if *D. microceras* is more closely related to *D. farinae* than to *D. pteronyssi-*

nus, one can predict that the allergens of *D. microceras* will have higher sequence homology with those of *D. farinae* than with those of *D. pteronyssinus*, even though there are currently no data available on the sequences of allergens of *D. microceras*. Why is such information of use? Probably the simplest and most pragmatic answer is that if the evolutionary relationships of dust mites were sufficiently understood to allow us to make predictions about the nature of their allergens (and how people make allergic responses to them), we would save research time and money.

Identification of mites in house dust

Most identification keys are constructed from combinations of numerous morphologic characters. The level of detail in the key is high in order that all the members of the taxon (e.g., family, genus, species) may be accommodated and discriminated. The optimal usage of this kind of key requires experience in mite taxonomy and morphology, and sometimes specialized optical systems and methods of specimen preparation. By way of contrast, a key to species in a particular habitat, such as house dust, does not require the same exhaustive treatment, for the simple reason that the vast numeric majority of mites in a given habitat will be represented by relatively few species. A case in point is the key to species recorded from house dust in Scandinavia (Appendix 1).

Most identification keys consist of written descriptions of the characters, usually in the form of couplets, and almost always in a telegraphic, technical style. Such keys to the two subfamilies of pyroglyphid house-dust mites have been published by Wharton (7) and, more recently, by Fain (8).

Keys to the genera and species of the storage mite families can be found in the handbook by Hughes (9). Pictorial keys for the identification of mites from house dust have been presented before by van Bronswijk & Sinha (10) exclusively for pyroglyphid house-dust mites, by Ottoboni & Piu (11) for “allergic mites”, and by Colloff & Spieksma (12) for “domestic mites”. Identification of immature specimens remains problematic for many taxa, although Mumcougulu’s key (13) differentiates larval and nymphal stages of *D. farinae*, *D. pteronyssinus*, and *Euroglyphus maynei*.

Recent developments in computer keys provide considerable scope for the development of user-friendly interactive keys, such as those written with DELTA (14). An interactive key to mites in house dust, written in DELTA format, is in preparation by the author.

Taxonomy of dust mites

Pyroglyphidae

Traditionally, the common name “house-dust mite” has been used collectively to include those members of the family Pyroglyphidae (order Astigmata) that live permanently in house dust. Most of the 49 species of Pyroglyphidae are nest-dwellers or feather-associates of birds (8). Only 13 are recorded from house dust, of which six, *D. pteronyssinus*, *D. farinae*, *Hirstia domicola*, *Malayoglyphus intermedius*, and *E. maynei* have been recorded in this habitat repeatedly and throughout the world. Another two species have more limited distributions, *D. siboney*, so far restricted to Cuba, and *D. microceras*, though frequently misidentified as *D. farinae*, predominantly found within Europe. Specific allergens have been isolated and purified from all the *Dermatophagoides* species listed above and from *E. maynei*, as reviewed by Colloff & Stewart (15).

Acaroidea and Glycyphagoidea

Mites belonging to the superfamilies Acaroidea and Glycyphagoidea have been referred to traditionally as “storage mites” or “stored-products mites”. More confusingly, they are also referred to collectively along with all other true house-dust-dwelling mites as “domestic mites”. The most important genera of the superfamily Acaroidea found in house dust are *Acarus* and *Tyrophagus*. Both are taxonomically complex, containing species that are morphologically very similar to each other. They are notoriously difficult to identify with any degree of certainty. In dust-mite surveys, the most commonly cited species of Acaridae are

Acarus siro and *Tyrophagus putrescentiae*. Most of these identifications are unreliable for the simple reason that the experience required to distinguish these species reliably and repeatably from their respective congeners has always been rare among acarologists. The genus *Acarus* was revised by Griffiths (16, 17), the latter paper containing a key to the 10 species then recognized. Hughes (9) gives a key to eight species. The most up-to-date key for *Tyrophagus* is that by Lynch (18), which contains modifications of keys by Johnston & Bruce (19) and Hughes (9). Griffiths (20) recognized some 21 species, of which 15 were regarded as rare or very rare, restricted to one or two records and limited geographic ranges. The remainder are common, cosmopolitan, economically important pests, some of them found in a very wide variety of habitats including soil, stored products, live plants, and dwellings.

The Glycyphagoidea contains species belonging to the following genera that are found in house dust: *Austroglycyphagus*, *Blomia*, *Chortoglyphus*, *Glycyphagus*, *Gohieria*, and *Lepidoglyphus*. Their biology and ecology within homes are probably the least known of the major taxa of domestic mites, yet they are the sources of some major allergens. The allergenic importance of the genus *Blomia* is especially noteworthy, and it was revised by van Bronswijk et al. (21, 22). Unfortunately, the exact identity of *Blomia kulagini* is in doubt because the type material has been lost, and it was redescribed on the basis of non-type material not taken from the type locality.

The diversity of pyroglyphid mites

Only members of the subfamilies Pyroglyphinae (three out of eight genera: *Euroglyphus*, *Hughesiella*, and *Gymnoglyphus*) and Dermatophagoidinae (all four genera: *Dermatophagoides*, *Hirstia*, *Malayoglyphus*, and *Sturnophagoides*) are found in house dust, with 13 species in all. The vast bulk of pyroglyphid diversity has been found exclusively on birds or in their nests in the tropics (28 spp.), especially west and central Africa (16 spp.), and Latin America including Cuba (nine spp.). Of the bird-associated pyroglyphid taxa, parrots, swallows and martins, sparrows, waxbills, weavers, woodpeckers, and starlings are among the most frequent hosts. Several species, now known to be important inhabitants of dust, were first recorded in atypical habitats (e.g., *E. maynei* in mouldy cottonseed cake). Virtually all bird-associated taxa have been recorded only from the type locality or have restricted distributions: only dust-associated species are widespread. The bulk of species have been

Table 2. Summary of phylogenetic relationships of orders of birds and subfamilies of pyroglyphid mites found on them

Bird orders	Mite subfamilies	Distribution
Piciformes	Pyroglyphinae	Asia
	Guatemalichinae	Africa
	Onychalginæ	Africa
Psittaciformes	Dermatophagoidinae	Africa
Apodiformes	Paralgopsinae	C. America
	Guatemalichinae	C. America
Passeriformes	Guatemalichinae	S. America
	Dermatophagoidinae	Africa
		N. America
	Pyroglyphinae	Australia
	Dermatophagoidinae	Africa
		C. America
	Pyroglyphinae	Africa
	Dermatophagoidinae	Africa
		S. America
	Onychalginæ	Africa
		S. America

described by just two people: Alex Fain and Jean Gaud, accounting for 23 species between them. The systematics of the family, especially subfamilial and generic concepts, is predominantly due to Fain (8). Both Fain and Gaud had historical research links with Africa, and Gaud worked exclusively on feather mites. Is the high diversity of African avian associates a real phenomenon, or is it an artefact of the research interests of these two authors?

Phylogenetic relationships of the family Pyroglyphidae

Theories about the phylogenetic relationships of Astigmata that inhabit houses were reviewed by Colloff & Stewart (15). In essence, the pyroglyphids were originally bird-nest dwellers but underwent a shift in habitat to the human nest, the bed, around the time of the first human settlement, associated with agricultural production, some 10000 years ago. The glycyphagoid and acaroid inhabitants of human dwellings made a habitat shift

from nests of small mammals and likewise encountered habitat similarities within homes, with food resources in the form of seeds, cereals, and other plant materials. Given the similarity of trophic niches of human dwellings to those available naturally, it is not surprising that a number of mite species have become associated with human habitations. Most importantly, many species, pyroglyphoid, glycyphagoid, and acaroid, appear to have retained the ancestral ability to feed on fungi (23). There has been no detailed phylogenetic analysis of the family Pyroglyphidae. However, the "host" relationships with birds are summarized in Tables 2 and 3. They indicate that the two subfamilies of pyroglyphids which contain species found in house dust, the Pyroglyphinae and Dermatophagoidinae, are the most widespread geographically and the most species-rich, and are associated with a higher diversity of avian taxa than those subfamilies that do not contain species that are found in house dust. This tends to suggest that the Pyroglyphinae and Dermatophagoidinae may represent ancestral taxa within the family, and that the subfamilial relationships are as shown in Fig. 1.

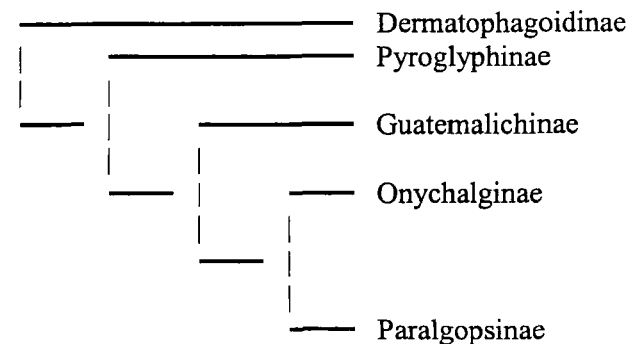


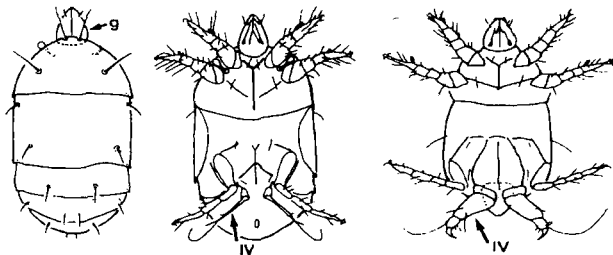
Fig. 1. Possible phylogenetic relationships of subfamilies of Pyroglyphidae.

Table 3. Diversity of species associations with birds within pyroglyphid subfamilies

Pyroglyphid subfamily	Number of major taxa of birds with which associated	Number of species in subfamily	Subfamily with dust-dwelling species?	Biogeographic regions in which bird-associated spp. are found
Dermatophagoidinae	5	18	+	Holarctic, Ethiopian, Neotropical
Pyroglyphinae	4	10	+	Australian, Oriental, Ethiopian
Guatemalichinae	4	3	—	Ethiopian, Neotropical
Onychalginæ	3	8	—	Ethiopian, Neotropical
Paralgopsinae	1	2	—	Neotropical

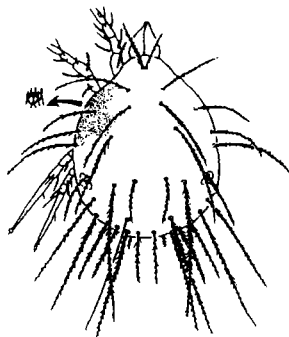
Appendix 1. Identification key to mites (adults) recorded from house dust in Scandinavia

1. Mites with modified legs IV (reduced, setiform on female, enlarged with a single tarsal claw on male); body with series of overlapping plates; gnathosoma (g) cone-like, enclosing minute palps and chelicerae family Tarsonemidae

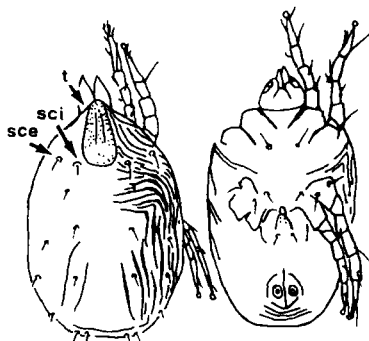


Mites not as above 2

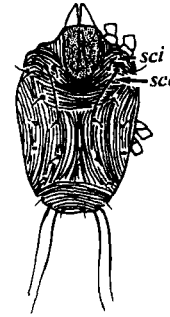
2. With striated cuticle. . family Pyroglyphidae . 3
With smooth or papular cuticle, long, serrated dorsal setae, and legs with long slim tarsi
. family Glycyphagidae



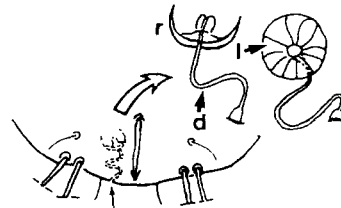
3. Setae *sci* and *sce* about the same length; tegmen (t) present. *Euroglyphus maynei*



Setae *sce* considerably shorter than *sci*; tegmen absent *Dermatophagoides*. 4

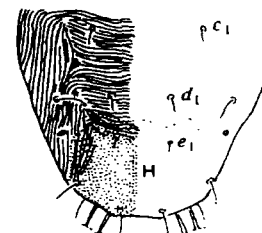


4. Females: base of receptaculum seminis U-shaped in cross section (r), broader apically than basally; circular with c. 10–13 lobes (l) when viewed from above; ductus bursae (d) of uniform thickness

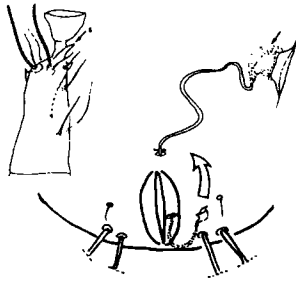


Males: with hysteronotal shield (H) longer than broad, extending anteriorly to point equidistant between setae c_1 and d_1 . . . *Dermatophagoides pteronyssinus* (Trouessart, 1897)

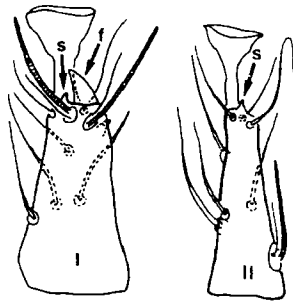
Females: receptaculum seminis not U-shaped in cross section; Males: with hysteronotal shield (H) as long as broad, extending anteriorly to point between setae d_1 and e_1 or slightly anterior of d_1 5



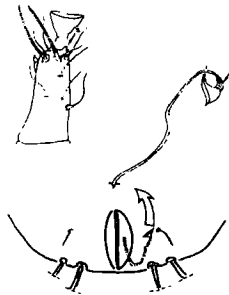
5. Females: Tarsi I and II with prominent, pointed apical spine (s); bursa copulatrix broad and strongly sclerotized in region adjacent to external opening (arrow); sclerotized section pointed anteriorly



Males: tarsus I with small apical protuberance (process *S*) and curved apical spine (f). Tarsus II with process *S* and no spine



.....*Dermatophagoides farinae* Hughes, 1961
Females: tarsus I with short, straight, blunted spine (s); tarsus II lacking spine. Bursa copulatrix narrow, weakly sclerotized in region adjacent to external opening



Males: tarsus I without small apical protuberance (process *S*) but with curved spine (f). Tarsus II without process *S* or spine. . . . *Dermatophagoides microceras* Griffiths & Cunnington, 1971

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