A new feather mite genus of the family Psoroptoididae (Acari: Analgoidea) from cassowaries

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Abstract
A new feather mite genus Hexacaudalges gen. n. (Psoroptoididae: Psoroptoidinae) is established based on the type species Megninia casuaricola Proctor, 2001, which was originally described from the southern cassowary Casuarius casuarius (Struthioniformes: Casuariidae). Morphological peculiarities of this genus, its taxonomic position within the family Psoroptoididae and possible origin are discussed. We also present a clarification of setal nomenclature for this family of mites.

Keywords: Birds, host–symbiont relationships, mites, morphology

Introduction
Feather mites are highly specialized permanent ectoparasites or commensals living exclusively on birds and inhabiting their plumage or skin (Gaud and Atyeo 1982a, 1996; Proctor 2003). These mites are of interest to ornithologists as well as acarologists because they are often considered to be indicators of host condition (see discussion in Proctor 2003), and because the phylogenetic relationships of the mites may reveal something of the evolutionary history of the hosts themselves (Mironov and Galloway 2003). In the course of taxonomic work on feather mites of the superfamily Analgoidea, the authors of the present study re-investigated the unusual feather mite Megninia casuaricola Proctor, 2001, collected from the southern cassowary Casuarius casuarius (L.) (Proctor 2001). This re-evaluation has led us to realize that it is a very peculiar representative of the feather mite family Psoroptoididae rather than of the Analgidae in which it was originally placed, and represents a new genus, which we have named Hexacaudalges gen. n.

This new genus displays several unique features among the Psoroptoididae and other taxa of the Analgoidea, but the structure of its tarsi allows us to confidently refer it to the subfamily Psoroptoidinae. The addition of Hexacaudalges brings the total number of genera in the subfamily to five (other genera are Anomothrix Gaud, 1973, Hyomesalges Gaud and Atyeo, 1967, Mesalges Trouessart and Neumann, 1888, and Psoroptoides Trouessart, 1919) (Gaud and Atyeo 1996). The present paper provides a diagnosis of the new genus based on...
the type species *M. casuaricola*, and gives a brief discussion of its morphological peculiarities, taxonomic position within the family, and host associations.

**Material and methods**

Paratype specimens mounted in Heinze polyvinyl alcohol (Evans 1992) deposited in the Zoological Institute, Russian Academy of Sciences (St Petersburg, Russia) were used for the present study. Other representatives of the family Psoroptoididae from the mite collection of the same Institute were used as comparative materials.

The diagnosis of the new genus is given in a standard format used for psoroptoidid taxa (Pérez and Ramirez 1996; Mironov 1997, 2004; Mironov and Pérez 2002). The nomenclature of idiosomal chaetotaxy follows Griffiths et al. (1990) and the leg chaetotaxy is that of Atyeo and Gaud (1966). Application of idiosomal chaetotaxy regarding Psoroptoididae follows the concept of Faccini et al. (1976) (see Discussion). Special terms for parts of opisthosomal lobes in males of Psoroptoididae are those of Černy (1974) and Mironov (2004).

**Family PSOROPTOIDIDAE** Gaud and Atyeo, 1982b  
**Subfamily PSOROPTOIDINAE** Gaud and Atyeo, 1982b  
**Genus Hexacaudalges** Mironov and Proctor, gen. n.  
Type species: *Megninia casuaricola* Proctor, 2001.

**Diagnosis**

*Both sexes.* Prodorsal shield a long and narrow plate, attenuate towards anterior end, not encompassing scapular setae *se, si* (Figures 1a, 3a). Setae *vi* absent. Laterocoxal setae *scx* absent. Tarsi I, II without ventral process (Figures 2a–d, 4a–b). Tibiae I, II with short and rounded ventral process. Posterolateral angle of femora I without acute indentation.

*Male.* Epimerites I fused into a Y. Epimerites II not connected to epimerites III, coxal fields II and III open. Opisthosoma with well-developed opisthosomal lobes; each split into three very long and narrow branches (Figure 1a, b): inner branches straight, with bifurcate apex and bearing setae *ps1* between this bifurcation; outermost branches slightly curved, with acute apex, and bearing subapical setae *f2*; intermediate branches with acute apex, with setae *h3* situated subapically, and setae *h2* and *ps2* at mid-level of the lobes. Genital apodemes as a short inverted U, genital apparatus very small, aedeagus shorter than genital arch. Adanal apodemes absent, small adanal shields anterior to setae *ps3* present. Tarsi I, II with two claw-like ventral setae: *s*—bifurcated apically, *la*—with single apex on tarsus I and bifurcated apically on tarsus II (Figure 2a–d). Legs III hypertrophied. Distal end of tibia III with short paraxial and antaxial spurs. Tarsus III with small apical spine; setae *s, w* lanceolate, moved to the base of this segment (Figure 2e). Tarsus IV greatly reduced, much shorter than tibia, with one dorsal spine, with setae seta *e, d* modified into tarsal suckers (Figure 2f).

*Female.* Epimerites I free. Hysteronotal shield absent. Posterior end of opisthosoma with two pairs of macrochaetae *h2, h3*. Copulatory opening situated dorsally, distant from posterior margin of opisthosoma (Figure 3a). Epigynium bow-shaped, small, separated
from epimerites, with setae $3a$ on its tips (Figure 3b). Tarsi I, II with all setae setiform (Figure 4a, b); ambulacral stalk of tarsi III, IV with ventral spine-like extension (Figure 4c, d).

**Differential diagnosis.** The new genus is referred to the subfamily Psoroptoidinae (see Discussion), but clearly differs from all other genera of the subfamily by the following characters. In both sexes, the prodorsal shield is narrow and does not encompass bases of scapular setae $se$, $si$; in males, setae $s$ and $la$ of tarsi I, II are claw-like, setae $s$ and $v$ of tarsi III lanceolate, opisthosoma with well-developed opisthosomal lobes split into three very long and narrow branches; in females, all setae of tarsi I, II setiform, hysteronotal shield absent.

In both sexes of other known psoroptoidine genera (Gaud and Atyeo 1967, 1982b, 1996), the prodorsal shield is trapezoidal and encompasses (or at least touches) the bases of the scapular setae, and tarsi I and II are similar in males and females and carry one claw-like

![Figure 1. *Hexacaudalges casuaricolus*, male. (a) Dorsal view; (b) ventral view.](image-url)
Figure 2. *Hexacaudalges casuaricolus*, leg segments of male. (a) Tarsus I, dorsal view; (b) same, ventral view; (c) tarsus II, dorsal view; (d) same, ventral view; (e) tibia and tarsus III, dorsal view; (f) tibia and tarsus IV, dorsal view, paraxial aspect. Scale bars: A (a–e); B (f).
setae. In males of other psoroptoidids, setae s, w of tarsi III are setiform, and opisthosomal lobes are not split into branches. Females of other genera always have hysteronotal shields.

The genus includes only the type species, *Hexacaudalges casuaricolus* (Proctor, 2001), comb. n.

**Etymology**

Contraction of *hexa* (L., six), *cauda* (L., tail) and the common combining form “alges” to reflect the unique structure of the opisthosoma in males, and placement of the genus in the superfamily Analgoidea.

**Discussion**

Morphological peculiarities of the genus *Hexacaudalges* and its host association allow us to formulate hypotheses regarding chaetotaxy of Psoroptoididae and evolution of this family.
The new genus *Hexacaudalges* is referred to the subfamily Psoroptoidinae, but in several morphological features, this genus is clearly distant from other members of the subfamily. The claw-like form of setae on tarsi I, II in males (Figure 2a–d) places this genus in the Psoroptoidinae, because it is one of the principal diagnostic characters of this subfamily (Gaud and Atyeo 1982b). However, these setae are claw-like only in the males of *Hexacaudalges*, while in the females they are setiform (Figure 4a, d). In typical Psoroptoidinae, the tarsi I, II of males and females are identical and only the setae on these tarsi are claw-like in both sexes. In males of *Hexacaudalges*, however, setae la of tarsi I, II are also claw-like.

The well-developed opisthosomal lobes in males of *Hexacaudalges* are a typical feature of the larger of the two psoroptoidid subfamilies, Pandalurinae, whereas in all previously named psoroptoidine genera the lobes are very poorly expressed. In contrast to pandalurines, in *Hexacaudalges* these lobes are split into three pairs of very long and narrow branches (Figure 1a, b), a unique feature of this genus. It is very easy to recognize the correspondence of each branch pair to certain parts of opisthosomal lobes in the typical pandalurines, males of which have a complicated shape of the opisthosoma (for instance in the genera *Chiasmalges* Gaud and Atyeo, 1967, *Mesalgoides* Gaud and Atyeo, 1967, and *Picalgoides* Černý, 1974). In *Hexacaudalges*, the outer pair carrying setae f2 matches the greatly elongated posterior opisthosomal angles of most pandalurines. The intermediate pair corresponds to the terminal lobar digits and lateral part of opisthosomal lobes in the typical pandalurines. The inner pair corresponds to the extremely elongated ledges of the terminal cleft; these rectangular ledges are most strongly developed in such pandalurine genera as *Mesalgoides* and *Chiasmalges*.

It is also easy to trace the homology of setae situated on opisthosomal lobes in *Hexacaudalges* with those in pandalurines, despite the fact that in the new genus the setae ps1 on the apices of the inner lobar branches appear to be placed more caudally than setae h3, which typically occupy this most terminal position. It is necessary to stress that the position of lobar setae in *Hexacaudalges* provides better support for the chaetotaxy concept proposed by Faccini et al. (1976) for the pandalurines than that used by Gaud and Atyeo
The differences between these concepts are in applying designations for setae ps2 and h2 (Mironov 2004). Comparison of setal placement on the lobar branches in *Hexacaudalges* and on opisthosomal lobes of typical pandalurines allows the following conclusions in regard to setal nomenclature in pandalurine males. In *Hexacaudalges*, the opisthosomal setae sitting at the mid-level of the intermediate branches and distinctly on their ventral side are without doubt setae ps2 (Figure 1b), because in males of most Analgoidea, only these setae of the posterior opisthosoma commonly occupy the ventral position (Analgidae, Pteronyssidae, Xolalgidae and others). These setae in *Hexacaudalges* obviously correspond to the setae sitting on the apex of the lateral lobar digits (or homologous extensions) in the pandalurines. In turn, the setae situated on the lateral margin of the intermediate lobar branches and directed slightly upward (Figure 1a) are undoubtedly setae h2. Therefore, in the pandalurines, the setae sitting in the lateral incision of the lobes (i.e. between setae f2 and ps2) are also setae h2.

As was stressed in the original description of *Hexacaudalges casuaricolus*, this species represents the first and so far only record of feather mites from the Casuariidae (Proctor 2001). Moreover, it is the single representative of the family Psoroptoididae known from all ratite families. If we entertain the hypothesis that the general mode of feather mite macroevolution involves co-speciation with their hosts (Gaud and Atyeo 1980; Dabert and Mironov 1999), and take into consideration the host association of *Hexacaudalges*, its morphological features, and rather distinct position within the family, one might hypothesize that this mite taxon originated on the cassowaries or their ancestor and has existed on this group of ratites for a long time. Other genera of the subfamily Psoroptoidinae are distributed on hornbills (Coraciiformes: Bucerotidae), with only one species of *Hyomesalges* Gaud and Atyeo, 1967 recorded on a different order (Cuculiformes). Members of the pandalurinae are more widely distributed among the orders Gruiiformes, Passeriformes, Piciformes, Psittaciformes, and Strigiformes (Gaud 1980; Gaud and Atyeo 1982b; Mironov 2004). How did a typically hornbill-associated mite taxon get on a ratite? It is unlikely that *H. casuaricolus*—a species specific to birds with a very special feather structure that are phylogenetically distant from more recently derived terrestrial birds—is a recent descendant of some psoroptoidines that migrated from Bucerotidae or Cuculidae. Given its morphological distinctiveness (which suggests long isolation from other psoroptoidines), it is more reasonable to conclude that *H. casuaricolus* is a relict representative of Psoroptoididae, which originated on the ancestors of Casuariidae. An extension of this idea, which may be drawn based on the scattered distribution of psoroptoidid supraspecific taxa among recent bird orders (Gaud and Atyeo 1982a, 1996; Mironov 2004), is that this family represents an ancient lineage of Analgoidea that has gone extinct on most bird orders and survives mainly on a few recent groupings of birds. However, we cannot exclude the possibility of an ancient host-shifting event that allowed psoroptoidines to move from bucerotids to ratites, e.g. through shared habitat. Better sampling of avian hosts in the southern hemisphere will allow us to test more thoroughly these and other hypotheses about psoroptoidid origins and co-evolutionary history.

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