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Source: Annals of the Entomological Society of America, 106(6):788-790. 2013.
Published By: Entomological Society of America
URL: http://www.bioone.org/doi/full/10.1603/AN13056

Adult Growth in Opilioacaridae With 1904 (Acari: Parasitiformes: Opilioacarida)

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Ann. Entomol. Soc. Am. 106(6): 788–790 (2013); DOI: http://dx.doi.org/10.1603/AN13056

ABSTRACT Mites in the order Opilioacarida are known to undergo postimaginal molting. The process has been associated with the ability to regain lost appendages, but may also result in growth and increases in numbers of specific setae. These processes were observed in four individuals, with two of these showing increases in setal lengths ranging from 8.1 to 16.6%. Qualitative growth, in the form of an increase from 5 to 6 in the number of *d*-type setae on the left palp, was observed in a single individual.

KEY WORDS postimaginal, molt, development, *Neocarus*, morphology

Increase in size (not increase in cuticular thickness) in arthropods is usually limited by the existence of a rigid exoskeleton, and is largely associated with molting. Second, molting in many arthropods is restricted to immatures. Thus, growth in the adult instar is uncommon. There are of course exceptions, such as in some Apterygota and Crustacea, which undergo postimaginal molts and may show molting-associated growth in the adult stage.

Most mites have only a single adult instar. However, Michener (1946), Imamura (1952), and Furumizo and Wharton (1975) reported postimaginal molting in species of, respectively, Trombiculidae, Arrenuridae (Trombidiformes: Parasitengona), and Pyroglyphidae (Sarcoptiformes: Astigmata), all members of the superorder Acariformes (Lindquist et al. 2009). Postimaginal molting has also been reported for Opilioacaridae (superorder Parasitiformes) (Coineau and Legendre 1975, Klompen 2000). In the latter group, such molting may be associated with the unusual ability to autotomize their legs as a defense measure. The ability to molt as adults allows them to recover from losing legs.

During ongoing studies of Brazilian Opilioacaridae, evidence of postimaginal molting could be observed in two species of *Neocarus* (one male and one female from Minas Gerais; one female from Parauapebas–Pará) and one of *Caribeacarus brasiliensis* (Bernardi et al. 2013) (one female from Parauapebas–Pará). All specimens showed characters of adults in the outer cuticle (e.g., presence of an ovipositor or of male sexual glands). In some, genital structures were also distinct in the new cuticle. These specimens allowed us to examine a previously unexplored aspect of postimaginal molting in mites, the potential for growth. An added reason for exploring this issue was a previous observation on adult polymorphism including the presence of "super" adults observed in some specimens of *Neocarus texanus* Chamberlin and Mulaik, 1942 and *Neocarus bajacalifornicus* (Vázquez and Klompen 2002). These adults have distinctly larger body size and larger setal counts (for selected types of setae) than "regular" adults. Our hypothesis was that postimaginal molting might explain this type of adult dimorphism.

Materials and Methods

Specimens were cleared in Nesbitt's solution and mounted on slides using Hoyer's medium (Walter and Krantz 2009); studies and drawings were with the aid of a phase contrast microscope (Zeiss Axioscope 3, Zeiss, Germany), connected to a drawing tube. The photos and measurements were made with the aid of an automated differential interference contrast (DIC) microscope (Eclipse 90i, Nikon, Tokyo, Japan) connected to a digital camera. All measurements are in micrometers.

Specimens are deposited at the Collection of Subterranean Invertebrates (ISLA), Section of Zoology de Zoologia, Department of Biology, Universidade Federal de Lavras, Lavras–MG, Brazil; and Ohio State University Acarology Collection (OSAL), Museum of Biological Diversity, Columbus, OH.

Results and Discussion

The role of molting in regaining previously lost limbs could be confirmed in a number of specimens

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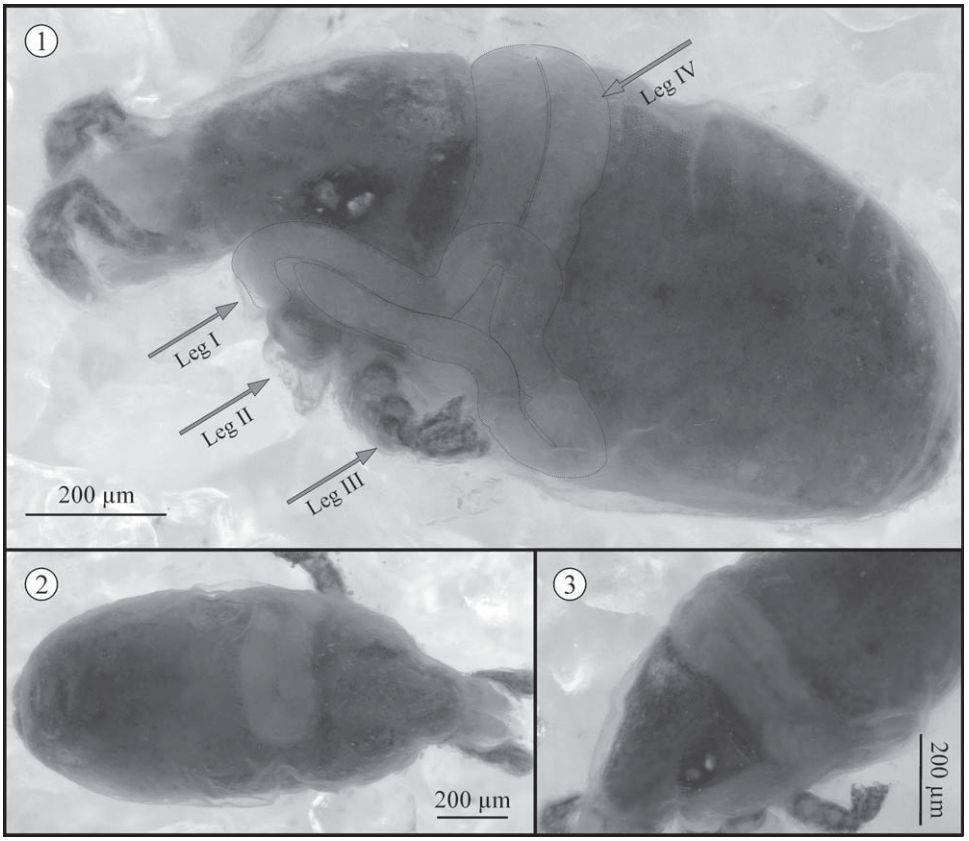


Figs. 1–3. *Neoacarus* n. sp., Tritonymph from Minas Gerais, Brazil. Details of the regeneration process of the leg I and IV: 1) lateral view, 2) dorsal view, 3) latero-dorsal view. Leg II and III were intentionally removed by the authors.

studied in this project. A tritonymph and two deutonymphs showed regeneration of one or two legs (Figs. 1–3). The new appendages are folded below the old cuticle, occupying their normal position and function only after ecdysis (see Coineau and Legendre 1975).

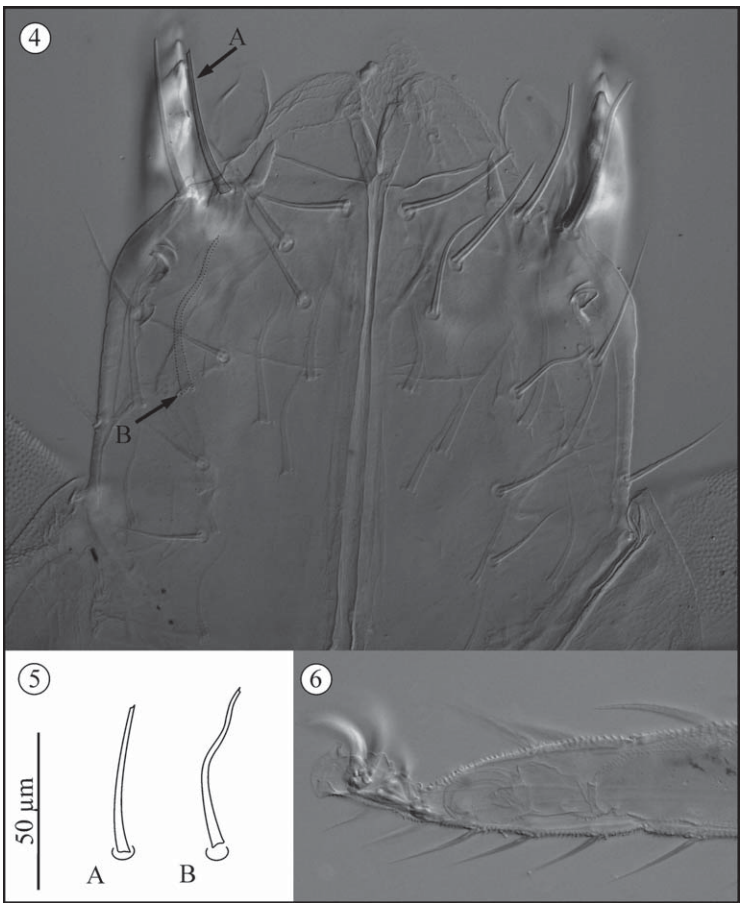
Comparative measurements of adults were made for selected structures on the subcapitulum and sternal region, structures 1) visible in both old and new cuticle, and 2) assumed to be largely unaffected by artifacts because of clearing and slide mounting. The latter limits selection to structures that are well sclerotized, rather than those showing relatively soft pliable cuticle. The size of homologous setae present on the external and internal cuticle, increased from 8.1 to 16.6% in size in two out of four specimens (Table 1). In addition, we observed an increase in the number of the *d*-type setae in the left palp (5–6) in one specimen (Figs. 4–6). However, this pattern was not uniform, as similar size increases could not be documented for the remaining two specimens. Still, it appears that growth associated with postimaginal molting does occur in Opilioacaridae, although its extent is modest and variable among taxa. Second, the size increase in these species (after just one molt) does not appear to be on a scale sufficient to explain the differences between regular and super adults, unless adults would molt repeatedly with modest size increases at each molt. In that case, one would expect a clear range of sizes from normal to super adults, something not observed among the relatively small numbers of specimens of *N. texanus* and *N. bajacalifornicus* examined. Although suggestive, the current results therefore do not allow definitive conclusions on whether growth associated with postimaginal molting can explain the existence of super adults.

Acknowledgments

We thank Fapemig for support to the Laboratório de Ecologia Subterrânea (PPM 00433-11), and Capes for financial support (PDSE 1202/12-0 and doutorate scholarship) to

Table 1. Setal size (µm) of female (*Neocarus*) adults before and after molting

Instar	Minas Gerais					Parauapebas–Pará	
	Subcapitular setae					Sternal setae	
	pl1	*cb1*	*cb2*	*cb3*	*cb4*		
♀Adult	16	42	44.8	50.8	54.7	40.7	39
♀Postimaginal molt	17.8	49	50.4	58	61.7	44	43
Percentage of growth (%)	11.2	16.6	12.5	14.17	12.79	8.1	10.25



Figs. 4–6. *Neoacarus* n. sp., female adult from Minas Gerais, Brazil. Details of the molting process: 4) subcapitulum, 5) leg III, 6) circumbuccal seta (*cb3*) on the old (A) and the new cuticle (B).

L.F.D.O.B. Also, R.L.F. is grateful to the National Council of Technological and Scientific Development (CNPq; process No. 301061/2011-4) for the financial support.

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Received 17 April 2013; accepted 12 August 2013.