

## On the Occurrence of Epizoic Cyanobacteria and Liverworts on a Neotropical Harvestman (Arachnida: Opiliones)<sup>1</sup>

*Key words:* algae; Aphanolejeunea; Brazil; Hepaticae; Lejeunea; Neosadocus.

EPIZOIC ORGANISMS GROW ON THE BODIES of living animals and are represented by bacteria, protozoans, algae, fungi, lichens, bryophytes, and a wide variety of walking and sessile animals. Epizoic plants are unusual on terrestrial organisms and have been observed mainly on tropical vertebrates (e.g., algae growing on hairs of sloths [Thompson 1972]; lichens inhabiting the carapaces of Galapagos giant tortoises [Hendrickson & Weber 1964]; and bryophytes on the head of a Mexican lizard [Gradstein & Equihua 1995]). Among arthropods, there are records of this kind of association for only two genera of weevils (Coleoptera: Curculionidae) endemic to New Guinea. The weevils inhabit the high moss forest ridges and moist summits and have been reported to carry small gardens of epizoic plants on their backs (Gressitt *et al.* 1965, 1968). Although many harvestmen live in moist places (Edgar 1990), the records of epizoic organisms on species of this order are restricted to nonpathogenic fungi (Machado *et al.* 2000). There is no report of any other cryptogam living epizoically on an arachnid.

From September 1999 to June 2000, we found Cyanobacteria (previously known as blue-green algae) and two liverwort species (Hepaticae: Lejeuneaceae) growing epizoically on the dorsal scute of four individuals of the harvestman *Neosadocus* sp., near *N. variabilis* (Mello-Leitão) (Gonyleptidae: Gonyleptinae), in the Cardoso Island (25°18'S, 48°05'W), south coast of São Paulo state, southeast Brazil. The climate is warm and wet, with a mean annual rainfall of 3000 mm and temperature of 21.2°C (Funari *et al.* 1987). The local vegetation is represented mainly by the coastal sand forest in the lowlands and the rain forest covering the mountains (500–800 m elev.) ca 3 km from the sea.

Two harvestmen, both adult males (11.7 mm and 11.5 mm body length), were found at night clinging to the vegetation in the coastal sand forest. The epizoic liverwort occurred together with a filamentous cyanobacterium that almost fully covered the harvestmen's backs (Fig. 1A). The greenish epizoic cover contrasted markedly with the brownish body and appendages of the animals. The other two individuals, one female (10.8 mm long) and one male (11.0 mm long), were found during the day under bark in the rain forest (ca 100 m elev.). These two individuals had cyanobacteria only, growing on the latero-posterior portion of the body and behind the eyemount. All four individuals were collected and maintained alive for three days in plastic boxes, suggesting that the growth did not affect the harvestmen's behavior and locomotion, and that these individuals were not colonized because they were sick. After this period, the harvestmen were preserved in 70 percent ethanol and deposited at the Museu de Zoologia da Universidade de São Paulo (MZUSP) as voucher specimens. Two permanent slides with fragments of the Lejeuneaceae prepared with Hoyer's fluid were deposited at the Instituto de Botânica, São Paulo, Brazil.

The green mat was found to consist of several species of Cyanophyta, and the liverworts were identified as *Aphanolejeunea subdiaphana* (Jovet-Ast) Pócs and *Lejeunea* aff. *confusa* Jones. The two hepatic species, which usually are found living on bark, leaves, and rocks (Schuster 1956, Jones 1972), have short colonization times (D. M. Vital, pers. obs.), and their propagules have adhesive cells that allow them to adhere to a variety of substrates. The two liverworts belong to the same family (Lejeuneaceae) as some of the species growing on the weevils from New Guinea. The occurrence of a *Lejeunea* species on harvestmen is the second record of this genus as an epizoic organism (Gressitt *et al.* 1965, 1968).

*Neosadocus* sp. is a common harvestman species in the Cardoso Island, where individuals are commonly found foraging on the ground and on the vegetation at night. During daylight, the harvestmen are mainly found sheltered among the leaf litter, under rotten bark of fallen tree trunks, and in the leaf axils of bromeliads; however, some individuals were observed attending tuna baits in the morning, suggesting that diurnal activity may also occur in this species. Females lay 26–64 eggs on the vegetation (including bromeliads) and take care of them (G. Machado, pers. obs.). Of the more than 130 individuals

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of *Neosadocus* sp. seen in the coastal sand forest during ten months of fieldwork only 2 were found with epizoic plants on their backs. On the other hand, 2 of 10 individuals found in the rain forest (a wetter environment) presented epizoic growth on the dorsal scute. There was a significant difference between the proportions of harvestmen with and without epizoic growth in these two environments (Yates' corrected  $\chi^2 = 4.58$ ,  $P = 0.032$ ).

Like many laniatorean harvestmen, *Neosadocus* sp. has several tubercles and setae on the dorsal scute. Moreover, adults of this species have depressions in the latero-posterior region of the dorsum and behind the ocular mount (Fig. 1B). The weevils bearing epizoic mosses also show several structural modifications in the dorsum, including pits, depressed areas surrounded by ridges and stiff setae, and pubescent areas protected by tubercles, which may retain moisture and favor the germination of the vegetative diaspores (Gressitt *et al.* 1968, Gradstein *et al.* 1984). The long life span (3–4 yr) and relatively low vagility of the weevils are characteristics that further enhance the establishment of the epizoic growth.

The liverworts reported here constitute the first record of a bryophytic plant growing on a living arachnid. Different than the New Guinean cloud forest plant–weevil symbiosis, the association reported here seems to be occasional; however, there are important similarities in the general characteristics of these two epizoic associations (Gradstein & Equihua 1995). First, the hosts have structures favoring the epizoids' anchorage that may provide protection for them, particularly in their early stages. Second, both hosts are slow-moving animals that occur in moist environments and have long life spans; laniatorean harvestmen live two to four years (Juberthie & Muñoz-Cuevas 1971, Cokendolpher & Jones 1991, Gnaspini 1995). Finally, the colonizing bryophytes are common and widespread species that are able to grow on ephemeral substrates and mature rapidly.

Harvestmen have a pair of glands opening at the anterior margin of the body that release repugnatorial secretions. The chemical nature of this liquid varies among species but there is evidence that it may function as a predator deterrent and as an antibiotic against bacteria and protozoa (review in Holmberg 1986). There is no report of the noxious action of these secretions upon plants. Moreover, *Neosadocus* sp. seems to be very reluctant to release its repugnatorial secretion, unlike other harvestmen species (Cokendolpher 1987, Machado & Vasconcelos 1998). Ten individuals were disturbed by squeezing their bodies with tweezers and none of them secreted exocrine gland secretions. The fact that *Neosadocus* sp. does not readily release its secretions may represent another feature that favors colonization by epizoids on this harvestman species.

It has been suggested that the weevils benefit from the presence of mosses on their backs by being camouflaged and thus protected from predators (Gressitt *et al.* 1968). If this is true, the greenish coloration on the harvestman's back promoted by epizoids could also function as a camouflage against visual diurnal predators. Experimental studies involving a great number of individuals are necessary to discover the evolutionary significance of this association.

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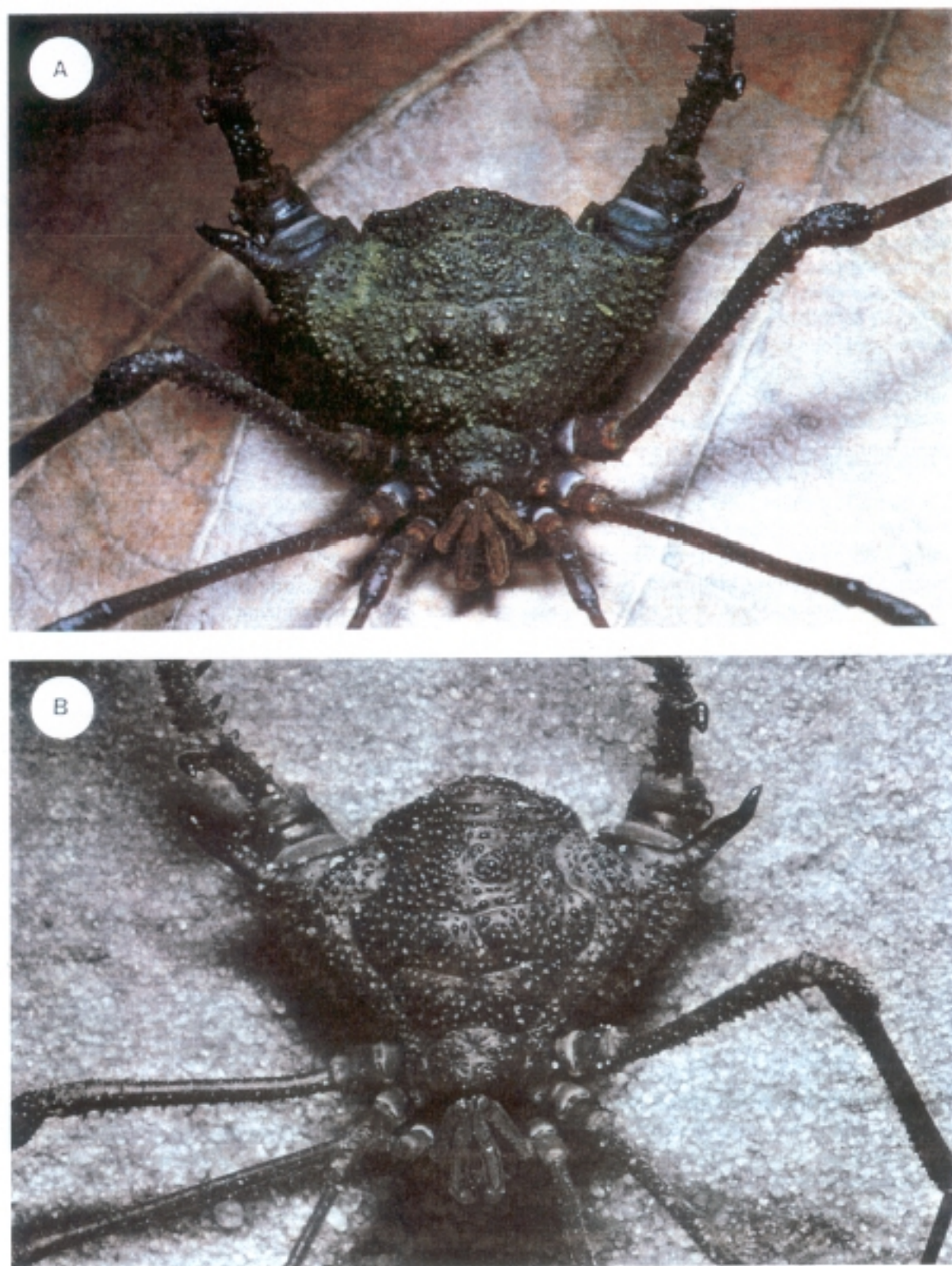


FIGURE 1. (A) Adult male of *Neosadocus* sp. (11.7 mm body length) from Cardoso Island, SP, Brazil, with the dorsum covered by epizoic Cyanobacteria and liverworts. (B) Adult male of *Neosadocus* sp. (similar size) without cover; note the tubercles and the depressions in the dorsal scute.

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