Boletín de la Sociedad Entomológica Aragonesa (S.E.A.), nº **57** (31/12/2015): 358–360. ISSN: 1134-6094

FIRST RECORD OF THE INTAKE OF LICHENIZED FUNGI BY DIPLOPODS (MYRIAPODA) IN EASTERN SUBREGION OF SUMAPAZ, COLOMBIA

Cristhian C. Castillo-Avila[1-2], Camilo Prado Sepulveda[1]
& Alexander García García[1]

[1] Universidad Distrital Francisco José de Caldas, Grupo de Investigación en Artrópodos "Kumangui", Bogotá, Colombia.
[2] cccastilloa@correo.udistrital.edu.co

Abstract: At Icononzo-Tolima, in the Colombian Andes, in a population of spirostreptid millipedes of the genus *Orthoporus* Silvestri, 1897 (Diplopoda: Spirostreptida) a feeding behaviour which includes lichens belonging to the family Parmeliaceae was discovered. The digestive tracts of three specimens were examined, and fragments of lichen thallus were found in each one. This paper presents the first record of lichen consumption by arthropods of the class Diplopoda.
Key words: Diplopoda, Spirostreptidae, *Orthoporus,* Parmeliaceae, feeding behaviour, Colombia.

Primer registro de la ingesta de hongos liquenizados en diplópodos (Myriapoda) en la subregión oriental del Sumapaz, Colombia
Resumen: En una población de milpiés espirostréptidos del género *Orthoporus* Silvestri 1897 (Diplopoda: Spirostreptida) procedente de Icononzo-Tolima, en los Andes colombianos, se descubrió un comportamiento alimenticio que incluye líquenes pertenecientes a la familia Parmeliaceae. Los tractos digestivos de tres especímenes fueron examinados, y se encontraron en su interior fragmentos de talo de liquen. En este trabajo se da a conocer el primer registro de la ingesta de líquenes en miriapodos de la Clase Diplopoda.
Palabras clave: Diplopoda, Spirostreptidae, *Orthoporus,* Parmeliaceae, comportamiento alimenticio, Colombia.

Introduction

Lichens or lichenized fungi are a symbiotic association between a fungus called mycobiont, and one or more photosynthetic organisms like a green algae and / or a cyanobacteria (Henssen & Jahns, 1974; Nash, 2009; Illana, 2009). Given that the mycobiont is the dominant component in the association, lichens are classified among fungi (Okasanen, 2006). Lichens occur in virtually all ecosystems, from the hot and frozen deserts, to rainforests and even in freshwater and marine environments (Aptroot & Seaward, 2003). These organisms can grow on a great variety of substrates, including rocks, soil, barks, fences, posts, fungi, bryophytes, leaves and even on the body of live insects (Hale, 1983; Hawksworth & Hill, 1984).

Lichens are consumed as food by a wide variety of animals, from invertebrates to humans (Morales *et al*., 2009). Among the invertebrates that have a diet including lichens there are mites, lepidopteran, springtails, dermapterans, snails and slugs (Perez, 1944; Richardson, 1975; Cadena, 2013). The majority of millipedes eat dead plant material and fragments of organic matter (Hopkin & Read, 1992). Some millipedes feed on live plants easily digestible, such as bryophytes (Bailey & Mendonca, 1990), young shoots or fine roots and could become crop pests (Baker, 1974). Few species are carnivorous (Hoffman & Payne, 1969) and several species feed on the remains of dead animals including snails (Srivastava & Srivastava, 1967).

To date it has not been reported in the literature lichens intake as part of the diet of millipedes. This is the first report of the feeding in juliform millipedes whose diet includes foliose lichens of family Parmeliaceae.

Methods

Field work was done at the Cafrerías village of Icononzo municipality, located to the east of the department of Tolima, Colombia (4º 10'55. 26'' N, 74º 31'54. 86'' W), at an altitude range 1000 - 1626 m.a.s.l. This area is part of the Sumapaz subregion along with the municipalities of Melgar, Carmen de Apicalá, Villa Rica and Cunday, located on the East Andes (Arias *et al*., 2014).

A direct and detailed observation of individuals was made, initially, in relation with lichens located in the bark of trees. Diplopods were identified to the family level following Hoffman *et al.* (1996), and the genus studied through the gonopod structure (Fig. 1) following Pocock (1895-1910) and Mauriès (1976). The digestive tracts of three individuals were dissected, immersed in water and their contents were examined.

Fragments of the lichens found in the dissections were identified following Carl & Hawksworth (2001). Samples of diplopods and lichens are preserved in the Colección de Artrópodos y Otros Invertebrados (CAUD-216), Museo de Historia Natural de la Universidad Distrital Francisco José de Caldas. The photographic record during sampling days was performed using a Samsung ES75 compact camera. Photographs of the organisms in the laboratory were taken using a ZEISS Stemi 2000-C stereoscope with AxioCam ERc 5s microscope camera, and Axio Vision Rel. 4.8 software.

Figure 1. *Orthoporus* sp., gonopod structure.

Figure 2. *Orthoporus* sp. photographed on lichens. Cafrerías village, Icononzo municipality, Colombia.

Figure 3. Example of fragments of the lichen thallus found. Scale 0.5 mm.

Results

131 individuals belonging to seven orders and 12 families, being the family Spirostreptidae the most abundant with 40 individuals, were collected during the sampling days (Table I).

Table I. Diplopods found in the Cafrerías village, Icononzo municipality, Colombia.

Order	Families	Individuals
Spirostreptida	Spirostreptidae	40
	Pseudaonannolenidae	7
Polydesmida	Apehelidesmidae	23
	Cryptodesmidae	8
	Cyrtodesmidae	2
	Chelodesmidae	13
	Furhmannosdesmidae	4
Spirobolida	Rhinocricidae	10
Siphonophorida	Siphonophoridae	10
Stemmiulida	Stimmiulidae	7
Glomeridesmida	Glomeridesmidae	5
Julida	Julidae	2
Total: 7	**12**	**131**

The individuals of *Orthoporus* (Spirostreptida, Spirostreptidae) were found on trunks and living leaves of plants belonging to the families Melastomataceae, Musaceae and Arecaceae; between litter and the soil surface; and, on posts with the presence of lichens that are part of the sampling site fences. The dissected specimens of this genus were found on lichens, with different growth forms located on tree trunks about 2 m above the ground, that apparently fed them (Fig. 2).

It was possible to verify with the dissection the digestive tract of three specimens of *Orthoporus* the presence of small fragments of the lichen thallus in each one, (Fig. 3). Lichens found belong to the family Parmeliaceae. It was not possible to determine lichens to lower taxonomic level due to the small size of the thallus fragments found.

Discussion

These millipedes may include certain amount of these lichenized fungi to supplement their nutrition. Polysaccharides are the major component of edible lichens, however the lipid and protein content is very low (Richardson, 1975). These complex polysaccharides could be broken into simple sugar units that millepedes can assimilate with the action of symbiotic microorganisms in the digestive tract.

Lichens generally synthesized a variety of secondary metabolites or “lichen substances” as an adaptation form to adverse environmental conditions, providing themselves with chemical protection (Cocchietto *et al*., 2002). Usnic acid, one of the most common and abundant known for its antibiotic, antifungal, antiprotozoarian action, is among these secondary metabolites (Cocchietto *et al*., 2002; Gómez, 2014; Illana, 2012; Ingólfsdóttir, 2002; Maciazg *et al*., 2014). Secondary metabolites could be counterproductive to the symbiont microflora and become toxic to the body. This can probably be avoided through rapid degradation of the lichen substances by microbes of the digestive tract and thus avoid being absorbed by the animal, as occurs in reindeers described by Sundset *et al.* (2009).

It is known that some orders of Diplopoda feed on some species of fungi through their mouthparts modified in a "beak" of possible suction function, with which they manage to obtain hyphae, as in some sifonoforids where the mandibles and the gnathochilarium are reduced (Read & Enghoff, 2009); this is the first report of the ingestion of lichenized fungi by millipedes with typical chewing mouthparts. It is necessary to further deepen the study in order to understand the nutritional value and the possible relationship between the

lichen substances and the physiological processes of these diplopods.

It was not possible to determine millipedes to species taxonomic level because in general *Orthoporus* gonopods are often quite similar between species, and in some cases can be found considerable intraspecific variation (Loomis, 1966; Causey, 1975; Mauriès, 1976; Shear, 1977; Krabbe & Enghoff, 1985). An investigation of the morphological and especially gonopodial variation might also give more clarification.

Acknowledgements

We thank Henrik Enghoff, Natural History Museum of Denmark, University of Copenhagen, for his kind assistance with *Orthoporus;* Sergei Golovatch, Institute for Problems of Ecology and Evolution, Russian Academy of Sciences, for his help in order to carry out this paper; Robert Lücking, Field Museum of Natural History, Chicago, USA, for his great help with the lichen determination. We would like to thank Oscar Cadena-Castañeda, Grupo de Investigación en Artrópodos "Kumangui", Universidad Distrital Francisco José de Caldas, Colombia, for his kind review of drafts of this publication. Thanks also to Clemencia Angel, Language Department, Universidad de los Andes, Colombia, for the suggestions and the linguistic revision of the manuscript.

References

(*) Available on www.sea-entomologia.org

APTROOT, A. & M.R.D. SEAWARD 2003. Freshwater lichens. *Freshwater Mycology. Fungal Diversity Research* Series, **10**: 101-110.

ARIAS, J.Y., A. GARCÍA & M. ROCHA 2014. Montane crabs (Decapoda: Pseudothelphusidae) from the cloud forests of the Sumapaz eastern subregion, Tolima (Colombia). *Boletín de la Sociedad Entomológica Aragonesa (S.E.A.),* **55**: 253-264(*).

BAILEY, P.T. & T.R. DE MEDDONCA 1990. The distribution of the millipede Onimatoiulus moreleti (Doplopoda: Julida: Julidae) in relation to other Onimatoiulus species on the south-western Iberian Peninsula. *Journal of Zoology*, **221**: 99-111.

BAKER, A.N. 1974. Some aspects of the economic importance of millipedes. *Symposia of the Zoological Society of London*, **32**: 621-628.

CADENA, O.J. 2013. The tribe Dysoniini part II: The genus *Markia* (Orthoptera: Tettigoniidae; Phaneropterinae), new species and some clarifications. *Zootaxa,* **3599**(6): 501-518.

CAUSEY, N. B. 1975. Desert millipedes (Spirostreptidae, Spirostreptida) of the southwestern United States and adjacent Mexico. *Occasional Papers Museum Texas Tech University,* **35**: 1-12.

COCCHIETTO, M., N. SKERT & P.L. NIMIS 2002. A review on usnic acid, an interesting natural compound. *Naturwissenschaften,* **89**: 137-146.

CRESPO, A., O. BLANCO & D.L. HAWKSWORTH 2001. The potencial of mitochondrial DNA for establishing phylogeny and stablishing generic concepts in the parmelioid lichens. *Taxon,* **50**: 807-819.

GÓMEZ, M.P., C. FERNÁNDEZ, H. GONZÁLEZ, P.K. DIVAKAR & A. CRESPO 2014. Parmeliaceae family: phytochemistry, pharmacological potential and phylogenetic features. *The Royal Society of Chemistry*. *RSC Adv*., **4**: 59017-59047.

HALE, E.M. 1983. *The Biology of Lichens*. Third edition. Edward Arnold, Baltimore, USA, 190 pp.

HAWKSWORTH, D.L. & D.J. HILL 1984. *The lichen-forming fungi*. Glasgow: Blackie, New York, 370 pp.

HENSSEN, A. & H. M. JAHNS 1974. *Lichenes*. Georg Thieme, Stuttgart, 467 pp.

HOFFMAN, R.L., S.I. GOLOVATCH, J. ADIS & J.W. DE MORAIS 1996. Practical keys to the orders and families of millipedes of the Neotropical region (Myriapoda: Diplopoda). *Amazoniana,* **14** (1-2): 1-35.

HOFFMAN, R.L. & J.A. PAYNE 1969. Diplopods as carnivores. *Ecology,* **50**: 1096-1098.

HOPKIN, S.P. & H.J. READ 1992. *The biology of millipedes*. Oxford University Press, New York, 233 pp.

ILLANA, C. 2009. Edible lichens. *Boletín de la Sociedad Micológica de Madrid,* **33**: 273-282.

ILLANA, C. 2012. Lichens used in traditional medicine. *Boletín de la Sociedad Micológica de Madrid,* **36**: 163-174

INGÓLFSDÓTTIR, K. 2002. Molecules of Interest Usnic acid. *Phytochemistry* **61**: 729-736.

KRABBE, E & H. ENGHOFF 1985. Morphological variability in a population of *Orthoporus antillanus* (Pocock, 1894) from Barbados, with notes on the taxonomic status of the species (Diplopoda: Spirostreptida, Spirostreptidae). *Ent. Scand.,* **15**: 333-339.

LOOMIS, H. F. 1966. Descriptions and records of Mexican Diplopoda. *Annals of the Entomological Society of America,* **59**: 11-27.

MACIAZG, M., G. WEZGRZYN & B. GUZOW 2014. Antibacterial activity of lichen secondary metabolite usnic acid is primarily caused by inhibition of RNA and DNA synthesis. *FEMS microbiology letters*, **353**(1): 57-62.

MAURIÈS, J.P. 1975. Spirostreptides (Myriapoda-Diplopoda) de Guyane française. Description de deux genres nouveaux. Compléments aux diagnoses des types d'espèces sud-américaines. *Bulletin du Muséum National d'Histoire Naturelle,* **333**(3): 1257-1275.

MAURIÈS, J. P. 1976. Spirostreptides (Myryapoda-Diplopoda) de Guyane française. Description de deux ganres nouveaux. Complenents aux diagnoses des types d'espèces sud-américaines. *Bulletin du Muséum National d'Histoire Naturelle Paris,* (3) 333, Zool., **235**: 1257-12275.

MORALES, E.A., R. LÜCKING & R. ANZE 2009. *Una introducción al estudio de los líquenes de Bolivia*. Serie Ecología No 1, Universidad Católica Boliviana San Pablo, 58 pp.

NASH, T. 2009. *Lichen biology*. 2a ed. Cambridge, Cambridge University Press, 498 pp.

OKSANEN, I. 2006. Ecological and biotechnological aspects of lichens. *Appl. Microbiol. Biotechnol*, **73**: 723-734.

POCOCK, R. I. 1895. 1910. Chilopoda and Diplopoda. *Biologia Centrali-Americana. British Museum (Natural History)*, London.

PEREZ, G.A. 1944. Lichens. Their biological and economic significance. *The Botanical Review,* **10**(1): 1-65.

READ, H.J. & H. ENGHOFF 2009. The order Siphonophorida - A taxonomist's nightmare? Lessons from a Brazilian collection. *Soil Organisms,* **81**: 543-556.

RICHARDSON, D.H.S. 1975. *The Vanishing lichens. Their history, biology and importance*. David & Charles, England, 231 pp.

SHEAR, W. A. 1977. Millipedes (Diplopoda) from caves Mexico, Belize and Guatemala. III. *Accademia Nazionale dei Lincei, Prob. Att. Sci. Cult.,* **171**: 235-265.

SRIVASTAVA, P.D. & Y.N. SRIVASTAVA 1967. Orthomorpha sp., a new predator millepede on Achatenia fulica in Andamans. *Experentia*, **23**: 776.

SUNDSET, M., P.S BARBOZA., T.K. GREEN, L.P. FOLKOW, A.S. BLIX & S. MATHIESEN 2009. Microbial degradation of usnic acid in the reindeer rumen. *Naturwissenschaften,* **97**: 273-278.