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Nutrient contents assessment in a cloud forest terrestrial isopod (*Ischioscia variegata*), using a non-destructive method, X-ray fluorescence. Higher P and Ca in the isopods collected in the canopy

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ABSTRACT

We used X-ray fluorescence (XRF-EDS) associated to Scanning Electron Microscope (SEM) to evaluate the nutrient content of the terrestrial isopod *Ischioscia variegata* collected from three different areas of the Venezuelan cloud forest. Nutrients measures can provide information about the foraging dynamic of our target species between soil surface and canopy vegetation. *Ischioscia variegata* was chosen on the basis of its extensive geographical distribution in the Venezuelan mountains, high motility and vagility. This terrestrial isopod colonizes the litter layer of ground soil and most vegetation and epiphytes in the canopy of mountain cloud forests. In these habitats, it feeds on a decayed organic matter. Of the X elements analyzed, the percentage intensity ratios of calcium and phosphorus (I% Ca/I% P) proved capable of identifying the provenance of the specimen. The lower cuticle is the part of the body which shows the greatest sensitivity to variations in nutrient distribution from different habitats and phosphorus is the best marker revealing these environmental differences. Comparisons between the percentage intensity ratios of P and Si (I% P/I% Si) from the lower cuticle and the digestive contents are promising markers for separating isopod capture sites from habitat provenance. Isopods found in the canopy zone have higher concentrations of some nutrients compared with those collected from ground litter especially P and Ca.

1. Introductions

The habitat which has the highest biodiversity in the world is the neotropical rain and cloud forest (Erwin, 1982, 1983; Hodginson and Casson, 1991; Paoletti et al., 1991; Basset, 1993; Watanabe, 1997). Its cycling of nutrients has been studied by several authors (Aubert and Tavernier, 1972; Herrera et al., 1978; Jordan and Herrera 1981; Paoletti et al., 1991), who report that nutrient availability is greater in the aerial part of the rain forest (the canopy) than in litter on ground soil. In addition, the canopy of mountain cloud forests contains a greater number of invertebrate species (Fig. 1) than does ground litter, probably due to the greater availability of space and also nutrients (Paoletti, 1989).

The different distribution of nutrients between soil and canopy in the mountain cloud forest of Venezuela influences the population dynamics of some ground-living invertebrates and their movement into the canopy, quite similar to the situation arising in periodically flooded ecosystems of the lowland Amazon basin (Erwin and Adis, 1982; Adis, 1997).

The main aim of the present work was to evaluate nutrient distribution in this three- dimensional forest system using the isopod (*Ischioscia variegata* as “probes” (Hopkin and Martin, 1984)). Starting from the hypothesis that the varying concentration of nutrients in canopy and soil is reflected in some body parts of invertebrates, we aimed at verifying if and where such a situation could occur.

We selected some different cloud forests in Venezuela having different location and vegetational profile to test the nutrient concentration of our isopod. This information aimed at revealing the distribution trends of isopods in their habitats, variations in nutrient availability, and correlations between behavior and food availability.

2. Materials and methods

2.1. Description of sampling area

Samples were collected during two expeditions to Venezuela in January-February 1987 at La Cristalina (Fig. 2) and Guacamaya areas and 1988 at Portachuelo, mainly in the Henry Pittier National Park and

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Fig. 1. Invertebrates sorted from one arboreal Bromelia un a cloud forest in Venezuela. The red arrow indicate *Ischioscia.* (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 2. Elfin forest La Cristalina near Boconò, Merida, Venezuela. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

other areas of the rain forest (Andes of Boconò). The park covers a surface area of 107,800 ha, mainly in the northern part of Aragua State, and a small part in the south-west of Carabobo State, north-central Venezuela, covering the Cordillera de la Costa. This mountain range is mainly formed of igneous and metamorphic rocks, and its soils normally have small concentrations of nutrients (Young, 1976; Zinck and Huber, 1978).

The rain forest, also called cloud forest (Selva Nublada), is generally subdivided into three zones according to altitude: 1100–1400 m a.s.l.; 1400–1800 m, Selva Nublada *sensu strictu* (Huber, 1986) and 1800–2500 m.

The study areas were:

1) Portachuelo (1250 m) Aragua-Pittier Park;
2) Guacamaya (1750 m) Maracay-Pittier Park;
3) La Cristalina (2000 m) Sub Paramo of Boconò, Boconò-Andes of Merida.

In Portochuelo, the forest intercepts winds of high humidity (*neblina*) and it is called Selva Nublada, although it is at a relatively low altitude. Guacamaya and La Cristalina lie in the true Selva Nublada. In Portachuelo, trees may reach heights of 10–45 m, with extensive foliage and abundant ground cover; in Guacamaya, the forest is slightly lower (20–30 m), with fewer large trees. In La Cristalina, the trees only reach 1–5 m, and some bromeliads become terrestrial (e.g., *Greigia albo-rosea* (Grisebach) Mez, *Guzmania* sp.) (Benzig, 1989).

The areas selected for collecting *Ischioscia variegata* were:

1) ground litter, by sieving in situ or free hunting with an aspirator;
2) branch zone, by beating branches over a range of 1.5 ÷ 4 m in height and collecting falling materials in an entomological umbrella (white cotton, 80 cm square);
3) suspended soils in bromeliads, by direct withdrawal and later sorting in the laboratory.

2.2. Organisms analyzed

The isopod *Ischioscia variegata* (Dollfuss, 1893), of the Philosciidae family and Oniscoidea group, later re-described by Vandel (1952), was chosen because it is relatively easy to capture, and has extensive geographical distribution and high vagility. Its physical characteristics (tapering form, long pereopods, smooth tergites, large eyes placed high on the head), suiting its ecological and behavioral strategies, indicated that this isopod falls in the runner category (Delamare Debouteville, 1951; Schmalfuss, 1984).

2.3. Sample preparation

Immediately after collection, specimens of *Ischioscia* were washed twice with deionized water, dried in filter paper, and preserved between layers of filter paper and air-dried; later, in the laboratory, they were preserved in a dry chamber at 45 °C.

The first condition to be satisfied was sample cleanliness, as observed by optical microscopy (Wild, mod. 5A), discarding material which appeared to be dirty or contaminated by fungi.

Subsequently, by means of needles, scalpels and tweezers, the lower and upper third *pereion* segment and the contents of the relative portion of digestive apparatus were separated from the body of each isopod, in the latter case after separation from gut membranes.

Sixty-six isopods were prepared for analysis, subdivided as follows:

- 22 from La Cristalina (4 ♂ and 4 ♀ from ground litter, 3 ♂ and 3 ♀ from branches, 4 ♂ and 4 ♀ from bromeliads);
- 22 from Guacamaya (4 ♂ and 4 ♀ from ground litter, 3 ♂ and 3 ♀ from branches, 4 ♂ and 4 ♀ from bromeliads);
- 22 from Portachuelo (4 ♂ and 4 ♀ from ground litter, 4 ♂ and 4 ♀ from branches, 3 ♂ and 3 ♀ from bromeliads).

The upper and lower cuticles were taken from all samples, but it proved impossible to gather gut contents from:

La Cristalina: samples 8 (♀, ground litter) and 18 (♂, bromeliads);

Guacamaya: sample 12 (♀, collected in the canopy vegetation with umbrella);

Portachuelo: samples 16 (♀, umbrella), 17–19 (♂, bromeliads) and 20–22 (♀, bromeliads).

Unfortunately, data for gut contents in the bromeliad area are not available, due to difficulties in preparing specimens.

Samples were identified by acronyms which, in order of appearance, are:

- area of capture: c (La Cristalina), g (Guacamaya), p (Portachuelo);
- progressive sample number (1, 2, 3, …);
- sex: m (male), f (female);
- capture sites: l (ground litter), u (branch), b (bromeliads);
- anatomical areas of analysis: uc (upper cuticle), lc (lower cuticle), gut (digestive contents).

Thus, c1mluc means La Cristalina, sample 1, male, ground litter, upper cuticle.