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ABUNDANCE AND PHENOLOGY OF SCHIZOMIDA (ARACHNIDA) FROM A PRIMARY UPLAND FOREST IN CENTRAL AMAZONIA

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ABSTRACT. There were 193 schizomids (hubbardids) collected from the soil (0–7 cm depth) during a 12 month study of a primary upland forest (37.5 ± 16.8 ind/m²/month) near Manaus. They were represented by *Surazomus brasiliensis* (Kraus 1967) and an undescribed species of a new genus (96% and 4% of the total catch, respectively). About 68% of all specimens of *S. brasiliensis* inhabited the organic soil layer (0–3.5 cm depth) where monthly catches of juveniles were positively correlated with soil temperature. Females were twice as abundant as males. The lack of a distinct reproductive period and the presence of juveniles (in particular the first nymphal instar) and adults (both sexes) throughout the year indicate a plurivoltine mode of life. Few specimens were caught on the soil surface, and none were on tree trunks or in the canopy. Abundance of *S. brasiliensis* is compared to that of the Palpigradi (microwhip scorpions) and Thelyphonida (vinegaroons) from the same study site.

The order Schizomida is comprised by about 180 described species. Few studies have been conducted on their ecology and biology. Schizomids are considered to be hygrophilous, photophobic, hemiedaphic inhabitants of soils, particularly in the tropics and subtropics. Some species are termitophiles, myrmecophiles, nidicoles or troglobites. (*cf.* Moritz 1993; Humphreys *et al.* 1989; Reddell & Cokendolpher 1995; Rowland 1972).

In Central Amazonian forests, schizomids represent less than 1% of the soil arthropods which mostly inhabit the top 7 cm (*cf.* Adis *et al.* 1987, 1989). Our material, obtained in a primary upland forest over a 12 month period, represents the very first contribution on the abundance and phenology of a Neotropical schizomid species: *Surazomus brasiliensis* (Kraus, in Kraus & Beck 1967).

STUDY AREA AND METHODS

Schizomids were collected between 1981–1983 in the course of ecological studies on Central Amazonian arthropods from a previously investigated and fully-described primary upland forest at Reserva Florestal A. Ducke (= Reserva Ducke; 2°55′S, 59°59′W; Penny & Arias 1982). The reserve is located on the Manaus-Itacoatiara highway (AM–010), about 26 km from Manaus. The forest is subject to a rainy season (December–May: average precipitation 1550 mm; 258.9 ± 36.8 mm/month) and a "dry" season (June–November: average precipitation 550 mm; 91.8 ± 43.8 mm/month and each month with some rain events; Ribeiro & Adis 1984). The yellow latosol (= ferrasol in Jordan 1984) of the primary upland forest had a 2–3 cm thick humus layer, interspersed with fine roots, and a thin surface covering of leaf-litter.

One ground photo-eclector (emergence trap) and one arboreal photo-eclector for trunk ascents (funnel trap) were installed in the forest (*cf.* Adis & Schubart 1984) and remained there from December 1981 to December 1982. Distribution of schizomids in the soil was studied between September 1982 and August 1983 (Morais 1985). Twelve soil samples were taken once a month every 2 m along a randomly selected transect. The split corer, composed of a steel cylinder with lateral hinges (diameter 21 cm, length 33 cm), was driven into the soil by a mallet. Each sample of 7 cm depth was then divided into two subsamples of 3.5 cm each for extraction of animals, following a modified Kempson method (Adis

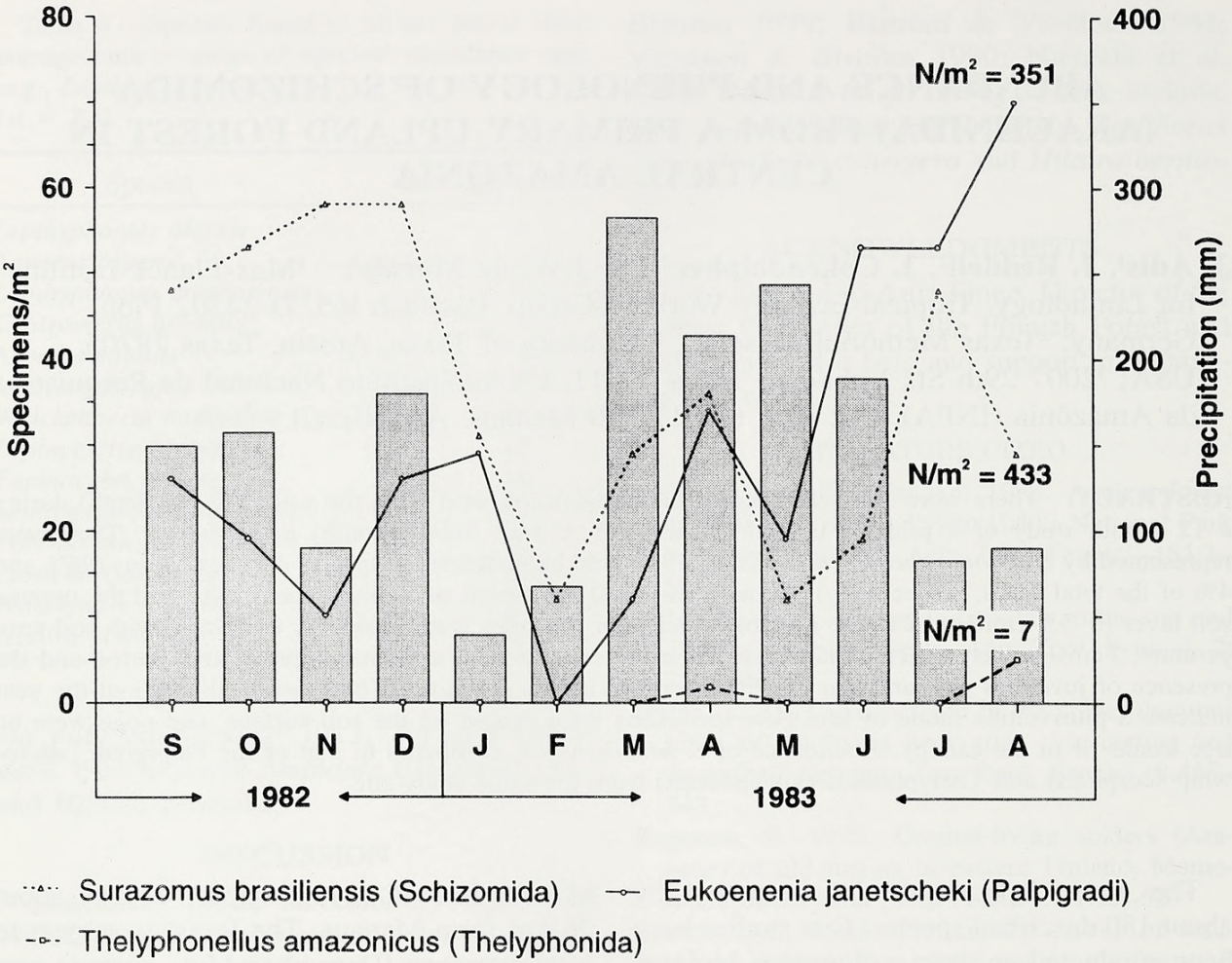

Figure 1.—Distribution of *S. brasiliensis* (Kraus 1967) (Schizomida), *E. janetscheki* Condé 1993 (Palpigradi) and *T. amazonicus* (Butler 1872) (Thelyphonida) in the soil. Samples taken monthly at 0–7 cm depth between September 1982–August 1983 in a primary upland forest near Manaus. (N = total number of specimens). Total precipitation per month given between sampling dates (= at the end of each month). The low rainfall observed in early 1983 was due to a strong El Niño-event (*cf.* Adis & Latif 1996).

1987). The combined area of the 12 samples represented 0.42 m^2. Calculated average abundances per m^2 are given with sample standard deviation. The monthly collection data of schizomids from the two soil layers in relation to changing abiotic conditions (precipitation, temperature and humidity of the air near the forest floor; moisture content, temperature and pH of the soil) were statistically evaluated with a linear, parametric correlation test (Cavalli-Sforza 1972) using the original field data (Morais 1985). In addition, the presence of schizomids in tree crowns of the primary upland forest was tested by fogging canopies with pyrethrum during the dry and rainy seasons (August 1991–July 1994; *cf.* Adis *et al.* 1997a).

All Schizomida sampled were classified as juveniles, subadults and adults (males and females, respectively; *cf.* Reddell & Cokendolpher 1995). Juveniles were tentatively assigned to three size classes, based on the length of the cephalothorax. The size classes presumably represent the three development stages in nymphs, apart from the subadult stage (*cf.* Brach 1976; Dumitrescu 1973; Rowland 1972).

Voucher specimens have been deposited at the Systematic Entomology Collections of the Instituto Nacional de Pesquisas da Amazônia (INPA) in Manaus, Brazil, at the Texas Memorial Museum, Austin, Texas and at the Muséum d'histoire naturelle in Genève, Switzerland.

RESULTS

Schizomida obtained from the primary upland forest at Reserva Ducke were represented

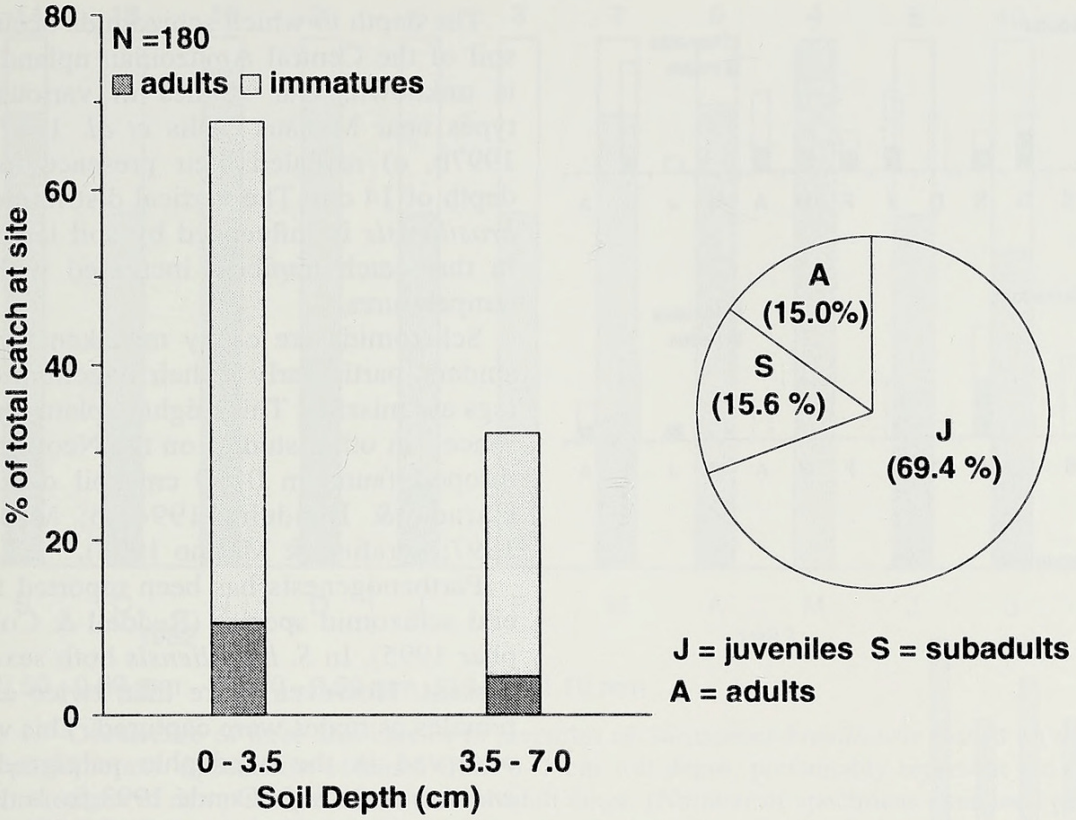

Figure 2.—Distribution of *Surazomus brasiliensis* in the soil according to soil depth, and percentage of developmental stages in a primary upland forest near Manaus. (Total catch = 100%) Samples taken monthly at 0–3.5 and 3.5–7 cm depths over a 12 month period. (N = total number of specimens).

by *Surazomus brasiliensis* (body length ≤ 4.3 mm without flagellum; *cf.* Kraus & Beck 1967; Reddell & Cokendolpher 1995) and an undescribed species (Reddell & Cokendolpher 1999) of a new genus (96% and 4% of the total catch, respectively).

A total of 193 schizomids was collected. Out of these, 99% could be identified to their developmental stages. Schizomids were mostly found in the soil and never caught on tree trunks or in the canopy. Only three specimens (adults of *S. brasiliensis*), were captured in pitfall traps inside the ground photo-eclector, while active on the soil surface. Schizomids represented 0.4% of the total arthropods extracted from soil samples within 12 months if Acari and Collembola are omitted (Morais 1985) and ≤ 0.1% when they are included (Adis unpubl. data). The abundance of Schizomida in 0–7 cm soil depth was higher than that of the Palpigradi (455 vs. 351 ind/m^2), whereas abundance of the Thelyphonida (7 ind/m^2) was much lower (corrected data of Fig. 1 in Adis *et al.* 1997b). This is also consistent for the dominant species in each order (Fig. 1). An average abundance of 37.5 ± 16.8 schizomids/m^2/month was recorded in 0–7 cm soil depth (*S. brasiliensis*: 36.1 ± 16.8 ind/m^2/month; new genus, new species: 1.4 ± 1.7 ind/m^2/month).

Most specimens of *S. brasiliensis* inhabited the organic soil layer (Fig. 2: 0–3.5 cm) and a few (32%) the mineral subsoil (3.5–7.0 cm depth). About 70% (25.0 ± 13.7 ind/m^2/month) of the total catch was represented by juveniles (Fig. 2), and 15% each by subadults and adults (5.5 ± 4.1 and 5.5 ± 4.6 ind/m^2/month, respectively). Sex ratio of adult males to females was 1:2.4 but instars of juveniles could not be sexed. No significant difference was found for the cephalothorax length between subadult males and subadult females (χ^2 *test*: $P < 0.05$).

The monthly abundance of juveniles in *S. brasiliensis* obtained from the organic soil layer (0–3.5 cm depth) was positively correlated with soil temperature (17.6–26.6 °C; average 23.8 ± 2.4 °C) (total catch: $r = +0.77097$, $P < 0.01$; $n = 12$). The total catches of specimens obtained during the dry season and the rainy season were similar: 48% versus 52%. However, there was no distinct

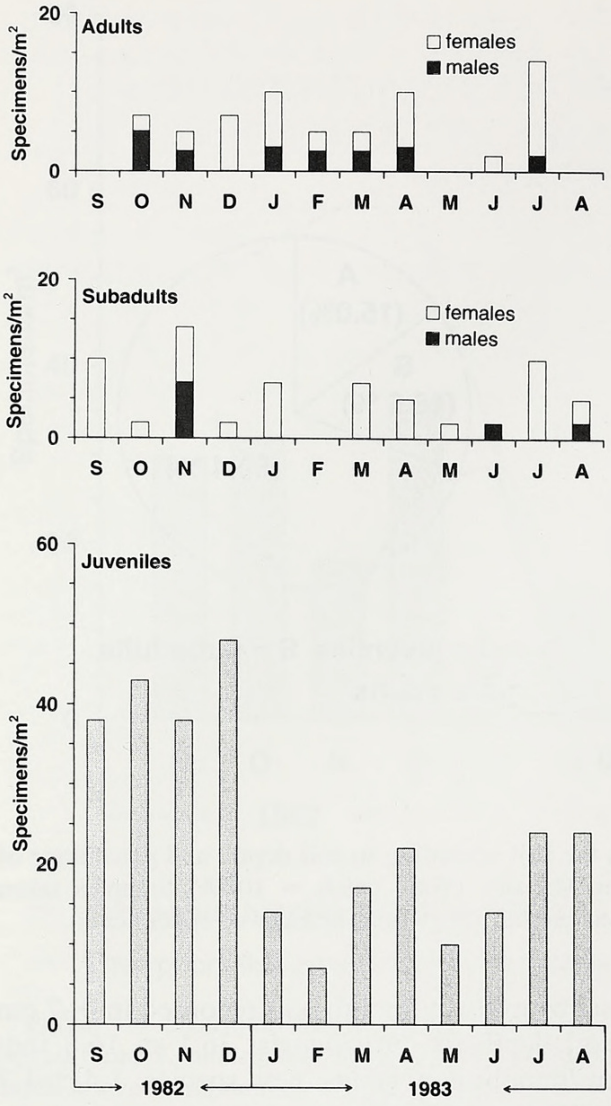

Figure 3.—Temporal occurrence of developmental stages of *Surazomus brasiliensis* in the soil (n/m² in 0–7 cm depth) of a primary upland forest near Manaus.

reproductive period because juveniles, in particular the first nymphal instar, as well as adults of both sexes, occurred throughout the year (Figs. 3, 4). These results indicate a plurivoltine mode of life.

DISCUSSION

The low number of schizomids in samples from the ground photo-eclector at Reserva Ducke indicates that these two species were rarely active on the soil surface. This conclusion is supported by another study at the reserve, in which apparently no schizomids were collected in 20 baited pitfall traps and in three or more ground photo-eclectors during a sample period of 12 months (Penny & Arias 1982).

The depth to which schizomids occur in the soil of the Central Amazonian upland forests is unknown. Our studies in various forest types near Manaus (Adis *et al.* 1987, 1989, 1997b, c) revealed their presence to a soil depth of 14 cm. The vertical distribution of *S. brasiliensis* is influenced by soil temperature in that catch numbers increased with rising temperatures.

Schizomids are easily mistaken for young spiders, particularly if their flagellum or front legs are missing. This might explain their "absence" in other studies on the Neotropical arthropod fauna in 0–30 cm soil depth (e.g., Harada & Bandeira 1994a,b; Macambira 1997; Serafino & Merino 1978).

Parthenogenesis has been reported for several schizomid species (Reddell & Cokendolpher 1995). In *S. brasiliensis* both sexes were present. However, more than twice as many females as males were captured. This was also observed in the euedaphic palpigrad *Eukoenenia janetscheki* Condé 1993 from the same study site (Adis *et al.* 1997b). Predominance of females assures the continuation of a species. This was also found for three species of Symphyla from the primary upland forest at Reserva Ducke and from a secondary upland forest at Rio Tarumã Mirím near Manaus where the number of females was 2–4× higher than of males (Adis *et al.* 1997c).

Surazomus brasiliensis is the only Amazonian schizomid species for which observations on the biology are available (Kraus & Beck 1967). Beck (1968) observed that animals in whitesand soils at Reserva Ducke predominantly feed on Collembola and Symphyla. Prey is searched by actively running around in a jerky manner (*cf.* Humphreys *et al.* 1989; Sturm 1973) and exploring the surroundings with the long and highly mobile front legs, which also serve as tactile instruments. Once the prey is perceived, the pedipalps are used to seize and transfer it to the chelicerae where it is cut during longitudinal and vertical movements. After ingestion and deposition of the remains on the soil, animals often groom themselves, particularly the long front legs and the flagellar region which is reached by folding the abdomen over the cephalothorax (= opisthosoma and prosoma, respectively, in Beck 1968). The grooming procedure is concluded by cleaning the pedipalps and the chelicerae. A similar behavior was reported for

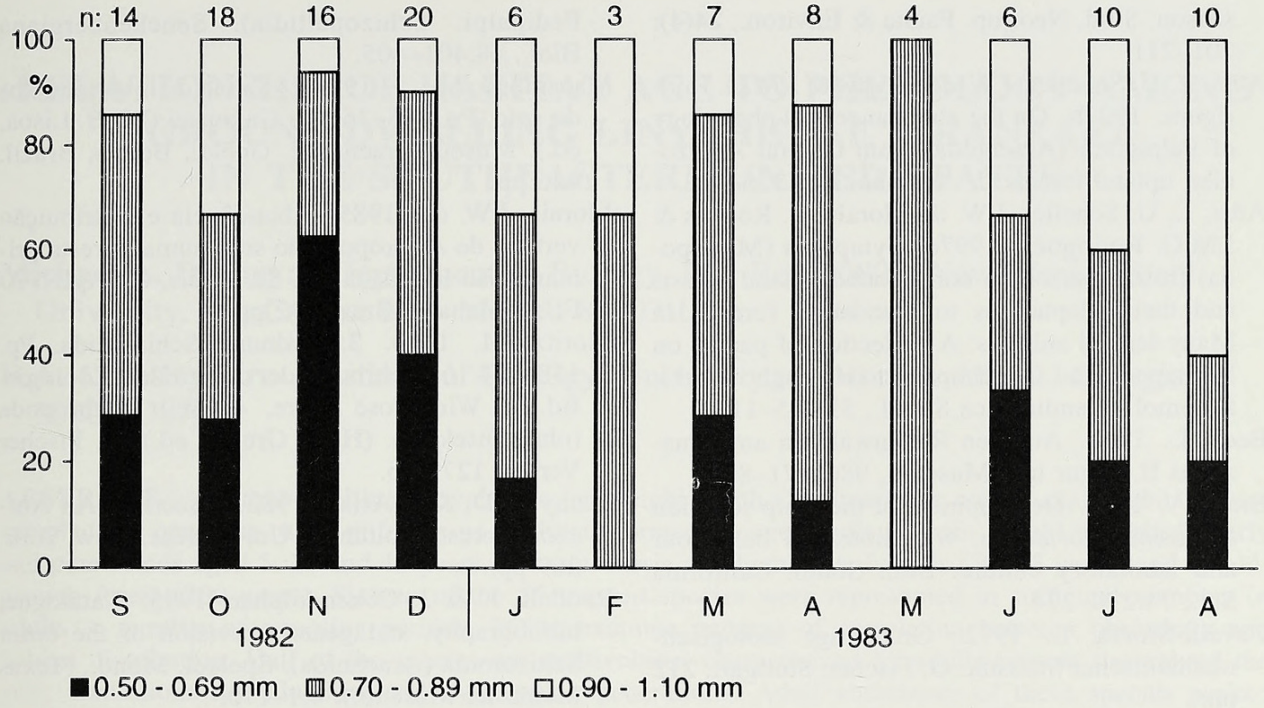

Figure 4.—Occurrence of three size classes in juveniles of *Surazomus brasiliensis* (based on the length of the cephalothorax). Specimens, obtained from 0–7 cm soil depth, presumably represent the three developmental stages in nymphs, apart from the subadult stage. (Number of specimens examined per month = 100%; 122 (97.6%) out of 125 juvenile specimens measurable).

two other schizomids: *Draculoides vinei* (Harvey 1988) from caves in western Australia (Humphreys *et al.* 1989) and for *Surazomus sturmi* (Kraus 1957) from the surroundings of Bogotá, Colombia (Sturm 1973). According to Beck, the mating behavior and indirect transfer of the spermatophore in *S. brasiliensis* is similar to that observed in *S. sturmi* (Kraus & Beck 1967; Sturm 1958, 1973).

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