First report on mass aggregation of opiliones in China

Aeshita Mukherjee [1], Burkhard Wilske [2] & Chen Jin [2]

[1,2] Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla, Yunnan Province, Menglun 666303, China
Email: [1] aesh2003@yahoo.com

Most harvestman species live in moist habitats and are frequently found under fallen trunks, among the leaf litter and inside caves, where some species can form large aggregations (Holmberg et al. 1984; Machado 2002). In fact, gregariousness is a widespread behavior among harvestmen, with reports for species from South and North America, Europe, and India (review in Machado & Macías-Ordóñez 2007). There are several hypotheses to explain why harvestmen aggregate, including: (1) collective selection of places with low risk of dehydration and with low light exposure, (2) reduction of air movement around each individual and consequent decreasing in evaporation rate, (3) strengthening of the chemical defenses by the collective action of the repulsive fluids secreted by the individuals, and (4) decrease in individual predation by a dilution effect (Holmberg et al. 1984; Machado 2002).

During a field trip to a seasonal rainforest on limestone in Xishuangbanna (21.91^{0}N & 101.28^{0}E), in the southern prefecture of Yunnan Province, southwestern China, a mono-species aggregation of the harvestman *Pseudogagrella* sp. (Sclerosomatidae: Gagrellinae) was found on the ground vegetation. The ground vegetation in the area of the aggregation was 30-40 cm tall and was dominated by the Malabar nut *Adhatoda vasica* Nees (Image 1). The aggregation consisted of five adjacent, clearly distinguishable sub-aggregations (hereafter referred to as patches), alongside a concrete-paved forest walk. Distances between the patches were between 2 and 10 m. The aggregation was first observed on 01 January 2005, and was monitored every two weeks during morning hours until 29 April 2005, which are winter months of the tropical-subtropical transition zone. A square plot (1 x 1 m) was used to estimate the number of individuals per patch. Sample individuals (n = 5) from each patch were brought to the laboratory for species and sex determination.

The majority of the individuals in the three-dimensional aggregation were made up of females (n ≈ 500). Only few males were found within each patch (n ≈ 10). Due to large aggregation size, since estimation of actual sex ratio was not feasible, we crudely estimated that less than 10% of the individuals in each patch were males. Individual patches covered an area between 1 and 6 m^2, and the total area occupied by the aggregation was about 15m^2. Harvestman densities within individual patches ranged from 10 to 30 individuals (mean ± SD = 20.0 ± 2.4 individuals, n = 45). Extrapolation of these densities resulted in an estimated aggregation size of ca. 300,000 individuals. To the best of our knowledge, this is the largest harvestman aggregation recorded so far – surpassing the previous record of 70,000 individuals of *Leiobunum* "*cactorum*" (Sclerosomatidae: Leiobuninae) aggregated on a candelabrum cactus in a Mexican desert (Wagner 1954).

During our observations, we found a few individuals (n ≈ 20) moving between patches. It was not evident whether there was a pattern of exchange of individuals between the patches. Upon disturbance, whenever we approached less than 1m close to a patch, all individuals moved away about 50cm over the vegetation but were nevertheless found in the original patch location during subsequent visits (n = 2 times). These observations suggest some kind of habitat selection and roosting fidelity, like that described for another sclerosomatid, *Prionostemma* sp., in Panama (Donaldson & Grether 2007; Grether & Donaldson 2007).

Although we do not know the precise date when the aggregation was formed, the aggregation persisted during the dry winter months i.e., between November and March. By 23 February, the number of individuals in the entire aggregation had decreased to about 3000. Although all the patches still existed, the majority of the individuals were now accumulated in a single patch. On 8 March, the aggregation still existed in the same place, and a few individuals were seen running at the sites

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Image 1. Mass aggregation of the harvestman *Pseudogagrella* sp. during dry winter months in a Chinese limestone forest.

previously occupied by the earlier patches, but they no longer formed an aggregation in these places. The total number of individuals was estimated to be around 1500-2000. At this time, we saw many of them carrying flowers of Malabar nut, but we did not see whether they were actually feeding on them. On 12 April, only about 200 individuals remained in the patch. They were inactive and reluctant to move on disturbances compared to the previous month. On our last visit, on 29 April, we did not find any individual. We checked the entire area in case they had shifted their roosting site, but the entire aggregation had disappeared.

Our observations suggest that individuals of *Pseudogagrella* sp. aggregate for a few months and then they probably disperse, die or hibernate until the next season. Winter temperatures in the subtropical-tropical transition climate usually range far above the freezing point (4-10^{o}C), even during the coldest month. This suggests a similarity between the aggregation we found in China and the over-wintering aggregations described for harvestmen from temperate zones, which were reported to occur inside caves or mines (Holmberg et al. 1984). The moderate ambient temperature within the caves from the temperate zone during chilling winter may be comparable to the temperatures under which the aggregation occurs in the ground-vegetation of a seasonal rainforest.

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